BB-REG-NET

Integrating Biodegradability into Life Cycle Assessments

The role of the OECD 301 biodegradability testing framework and its use in Life Cycle Assessment

Lead Author: Maryam Hoseini*

Contributing Authors: Stuart Walker*, Rachael Rothman*, Jen Vanderhoven**

Organisation: University of Sheffield*, BBIA**

Integrating Biodegradability into Life Cycle Assessments

The role of the OECD 301 biodegradability testing framework and its use in Life Cycle Assessment

Environmental Working Group

Report Reference: B1

Date: 14th April 2026

Version: FINAL

Classification: Public

Lead Author: Maryam Hoseini*

Contributing Authors: Stuart Walker*, Rachael Rothman*, Jen Vanderhoven**

Organisation: University of Sheffield*, BBIA**

Executive Summary

Life Cycle Assessment (LCA) is a standardised method used to evaluate the environmental impacts of a product, process, or service across its entire life cycle, from raw material extraction through production and use to end-of-life. Widely used to inform sustainable decision-making, LCA plays an important role in comparing the environmental performance of different materials and technologies. However, LCAs can contain methodological biases, including those affecting both fossil-based and bio-based materials. In particular, biodegradability and end-of-life environmental fate are often not well represented as impact categories, meaning potential benefits or trade-offs associated with biodegradation may be overlooked.

The OECD 300 series of biodegradability tests are designed to measure how readily, and quickly organic substances are broken down by microorganisms under controlled laboratory conditions. Although these tests have limitations, data gaps, and challenges in real-world applicability, they still provide useful information, particularly the OECD 301 "ready biodegradability" test.

Using biodegradability standards alongside LCA offers opportunities to improve product-specific modelling within LCAs and to address some of the gaps in how end-of-life impacts are represented. However, challenges arise because OECD 301 testing conditions do not fully reflect real-world environments. Despite this, OECD 301 data is often more product-specific than the generic assumptions typically used in LCA. When applied appropriately, it can therefore improve the representativeness and robustness of LCA results, while helping to reduce biases in the assessment of both fossil-based and bio-based materials.

Recommendations

We offer five recommendations related to the use of OECD 301 data for LCA practitioners undertaking comparative LCA of fossil and bio-based or biodegradable materials:

- Use OECD 301 data in LCA where possible and relevant.
- Be aware of the limitations of OECD 301 data, particularly related to laboratory versus real world conditions.
- Collect and calculate supporting information to bridge gaps in OECD 301 and LCA data and improve representativeness.
- Present information transparently and with appropriate sensitivity and uncertainty analysis.
- Continue to move towards fair comparison between fossil and bio-based materials by adopting the seven impact categories highlighted in a previous report; namely, Biodegradability, Bioaccumulation, Persistence, Microplastic formation, Biodiversity impact, Litter, Global warming potential (biogenic) - supported by OECD 301 data where available.

This report details the context and challenge which precipitate this work, the development of these recommendations, and describes the detailed which underpins these recommendations.

Contents

1 The potential of bio-based and biodegradable chemicals and materials

World-leading sustainable bio-based chemicals and materials (BB-Materials) developed, designed and manufactured in the UK, offer a once-in-a-generation opportunity to transition away from oil-and-gas, creating a resilient-engine for net-zero, and securing and growing hundreds-of-thousands of highly skilled jobs.

Chemicals are in everything we use in our daily lives: food, textiles, energy, batteries, defence products, mobile phones and medicines, enabling food security, the clothes we wear, heating our homes, affording national security, enabling communications and delivering treatments for diseases.

Today, almost all chemicals are made from fossil sources, being responsible for around 10% of global greenhouse gas emissions. A recent Innovate UK report '*Sustainable Carbon for the UK Chemicals Industry*', highlighted a UK Chemicals Sector ambition, that By 2050, it will have doubled in size, sourcing 30% of its carbon feedstock from biomass[1], with manufacturing of just 12 biochemicals having potential to contribute 5.2 million-tonnes CO_2e GHG-savings and £1.6 billion annually to the UK economy[2]. Through accelerating the commercialisation of BB-Materials, if 30% of chemicals could be bio-based by 2050, this has potential for £204 billion annual income.

The UK is the home of BB-Materials academic excellence, but other areas of the world are already implementing policies and regulations to drive this sector forwards and the UK is rapidly losing this competitive advantage[3].

[1] Innovate UK, 2024, unpublished
[2] DESNZ, 2024, unpublished
[3] BB-REG-NET: From Research to Revenue: The Case for Scaling UK Bio-based Innovation, J. Hobson, J. Vanderhoven, 2025, www.bb-reg-net.org.uk

2 Key Challenges in Life Cycle Assessment

2.1 Introduction

Life Cycle Assessment (LCA) is a foundational tool for the evaluation of sustainability and environmental performance of a product or process and is particularly relevant in the context of transitioning to a bio-based economy. The methodology allows for the quantification of environmental impacts at the product level by modelling the material and process inputs and outputs associated with each stage of a product's life cycle, from raw material extraction through manufacturing, distribution, use, and end-of-life disposal or recycling. This comprehensive approach makes LCA especially powerful when assessing novel bio-based products, which often rely on renewable resources and novel processing routes that differ significantly from conventional fossil-based systems, to enable a comparison of the most sustainable chemical and materials options.

For bio-based chemicals and materials, where sustainability claims are common but often difficult to verify, LCA provides an evidence-based framework for comparing impacts and identifying opportunities for improvement. It enables stakeholders to understand the trade-offs involved, such as land use, water consumption, or potential shifts in emissions from one life-cycle stage to another. As the field continues to develop, so too does the quality of insight that can be achieved. This is heavily dependent on the granularity and accuracy of input data, including details such as material composition, geographical sourcing, processing energy demand, and waste generation.

The depth and value of an LCA study are defined by the objectives of the assessment, the robustness and resolution of the data available, and the complexity of interpretation required. For relatively simple comparisons such as between two fossil-based packaging materials, an LCA can provide indicative guidance by evaluating key impact categories like greenhouse gas emissions, energy use, and resource depletion. However, for more complex assessments, especially where bio-based alternatives are involved and the systems under study include interdependent or novel processes, a more sophisticated modelling approach is required.

In these cases, a detailed LCA may incorporate a full digital model of the manufacturing process, effectively functioning as a "digital twin" of the real-world system. This allows for scenario testing, hotspot identification, and sensitivity analysis that can inform both strategic decision-making and process optimisation. Such digital twins are particularly valuable in bio-based innovation, where novel feedstocks, technologies, and supply chains are emerging and must be assessed holistically to ensure they deliver genuine sustainability benefits.

2.2 Key Challenges

Research during the Discovery phase of BB-REG-NET, as well as preceding work[4], highlighted major challenges in the comparison of fossil-based and BB-Materials through LCA. Some challenges are not unique to BB-Materials but are problematic due to the need to compare fossil-based and BB-Materials, and the fact that these challenges apply more strongly to BB-Materials- creating a bias that can unintentionally skew results in favour of fossil-based materials.

Figure 1 illustrates results from the Discovery Phase of BB-REG-NET and demonstrates that whilst the sector is highly aware of the value of LCA, standards are perceived as favouring fossil materials over BB-Materials, and regulations are perceived to be unsatisfactory.

[4] Life cycle assessment of bio-based and fossil-based plastic: A review, S. Walker, R. Rothman, Journal of Cleaner Production, 2020

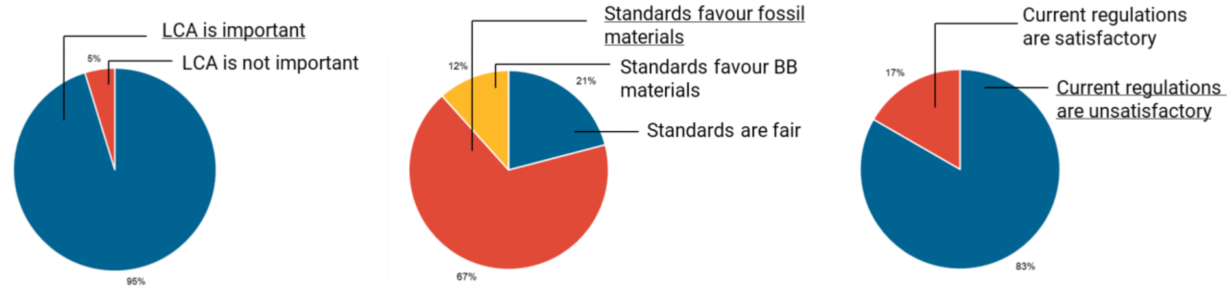

Figure 1: Findings from BB-REG-NET Discovery phase, illustrating understanding of the importance of LCA, but concern over standards and regulations. 43 responses to online survey of BB-Materials sector business leaders, July – September 2024

The recent BB-REG-NET Bio-Barometer survey[5] also highlighted that LCA is the main concern that stakeholders have in terms of the development and commercialisation of BB-Materials (Figure 2).

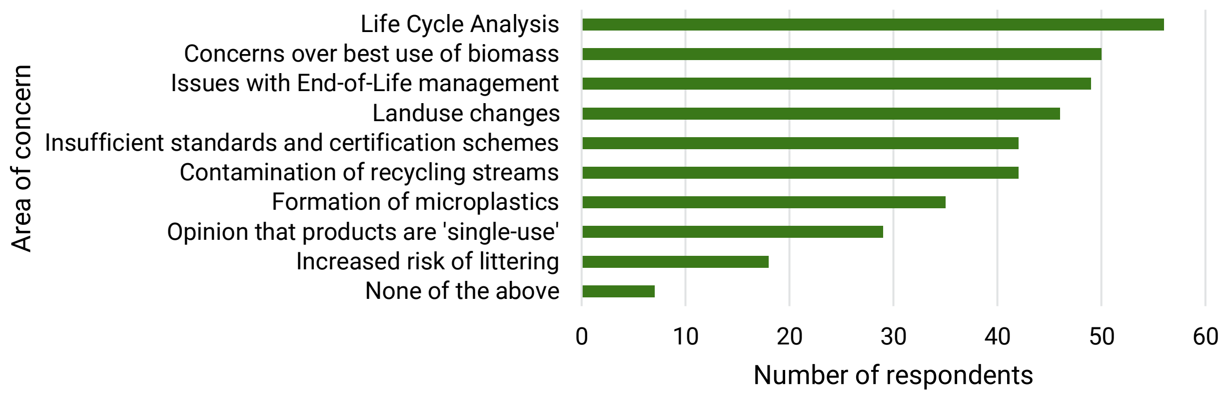

Figure 2: Results of BB-REG-NET Bio-Barometer survey: Stakeholder areas of concern related to BB-Materials.

Three key challenges identified during the initial stages of BB-REG-NET are described in brief in the following sections, namely, Incomparability, Implicit Bias, and End-of-Life (EoL) treatment, as described below:

- **Incomparability:** The inability to fairly compare two or more materials or systems due to differences in assessment methods, assumptions, or data used in the evaluation.
- **Implicit Bias:** Unintentional preference or disadvantage built into standards or methods, often favouring established materials (like fossil-based) by how impacts are assessed, or data is selected.
- **End-of-Life (EoL) Treatment:** The process by which a product is managed after its use phase, including options like recycling, incineration, landfill, or composting—each with different environmental impacts.

2.2.1 Incomparability

Materials can become difficult or even impossible to compare fairly when they are assessed using different methods, standards, or frameworks. This issue, known as incomparability, often arises when different types of materials, such as BB-Materials and fossil-based materials, are evaluated using inconsistent assumptions or system boundaries. For example, considering only emissions related to the manufacture of a fossil-based polymer against those of the raw materials, manufacture and end-of-life treatment of a BB-material would yield incomparable results.

These inconsistencies can unintentionally disadvantage innovative materials, particularly BB-Materials, by failing to capture their full environmental profile or by favouring the long-established norms of fossil-based systems. To support fair and meaningful comparison, it is essential that standards promote consistent and transparent methods across material types irrespective of their production or manufacturing process, with a

[5] BB-REG-NET Bio-Barometer Survey: Shaping the Future of Bio-Based and Biodegradable Solutions. April 2025, J. Vanderhoven, www.bb-reg-net.org.uk

comprehensive and balanced view of environmental performance. The challenge of incomparability, particularly related to standards, has been highlighted in previous BB-REG-NET work[6] .

2.2.2 Implicit bias

Implicit bias in sustainability assessments can unintentionally favour fossil-based materials, depending on how the assessment is carried out. This bias often comes from the choice of methods or standards used in the analysis. Two common areas where this can happen are: (1) how environmental impacts are shared between a product and its co-products, and (2) how carbon from biological sources (biogenic carbon) is handled in the assessment.

Biogenic carbon is especially important when comparing BB-Materials with fossil-based materials. If it isn't properly considered, the results can be misleading. For example, a bio-based product might seem to have a lower environmental impact if only the carbon absorbed during growth is counted (as in a cradle-to-gate assessment), while ignoring emissions released at the end of its life. On the other hand, if only the emissions are counted and not the carbon uptake, the same product could seem worse for the environment than it really is.

Standards that define which impact categories to include can also introduce bias by shaping the results in a way that doesn't fairly reflect the benefits or trade-offs of BB-Materials. Previous BB-REG-NET work has addressed the challenges of impact category selection and proposed seven impact categories to enhance comparability between material types[7].

2.2.3 End-of-life treatment

The third key area of challenge identified in this work is end-of-life (EoL) treatment. Challenges in this area can be caused by a variety of reasons including standards (which can result in unfair or misleading comparisons between materials when they allow only a limited set of end-of-life treatment scenarios to be considered), or data. In the context of data, the challenge of data collection for EoL treatment of BB-Materials is the primary source of difficulty. This is partially related to the variety of possible EoL routes for BB-Materials, but also commonly the lack of high-quality material-specific data on EoL treatment. This is particularly problematic for innovative BB-Materials that are designed to follow specific alternative EoL pathways such as composting or anaerobic digestion. If due to lack of data these materials are instead assessed under default or generic scenarios, such as incineration or landfill, this not only misrepresents the actual environmental performance of the material but also fails to acknowledge the system-level benefits composting can offer, such as nutrient recycling, reduced landfill burden, and, in some cases, lower greenhouse gas emissions.

This issue becomes even more critical when BB-Materials are assessed, due to the role of biogenic carbon. Without accurate data, a compostable bio-based material may be modelled as being incinerated at EoL, meaning that any biogenic carbon it contains is considered immediately emitted as CO_2, even though composting may lead to partial carbon retention in soil in the form of organic matter or may result in different gas emission profiles (e.g., more methane in anaerobic conditions if poorly managed, or CO_2 under aerobic composting). Methods that do not allow for such distinctions, or that simplify biogenic carbon treatment into fossil-like behaviour, can therefore penalise BB-Materials unfairly, highlighting the need for reliable EoL data.

[6] BB-REG-NET: Standardised but unfair? S. Walker, R. Rothman, M. Hoseini, J. Vanderhoven, 2025, www.bb-reg-net.org.uk
[7] BB-REG-NET: Seven Steps to Fairness. S. Walker, R. Rothman, A. Newman, J. Vanderhoven, 2026, www.bb-reg-net.org.uk

3 Addressing Key Challenges

Previous BB-REG-NET work[8] studied LCA standards and considered how the adoption of various ISO and EN standards may lead to comparability challenges and considered the potential for adoption of a wider range of impact categories. This primarily addressed the first and second key challenges identified above: incomparability and implicit bias.

This work now addresses the third key challenge: end-of-life treatment. Specifically, this work studies the OECD Biodegradability test framework, and considers challenges and opportunities related to the integration of these methods into Life Cycle Assessment.

This work aims to understand and make methodological recommendations to address the challenges around incorporating test data into end-of-life calculations in LCA. This is the focus of the remainder of this report.

3.1 OECD Biodegradability Tests

The Organization of Economic Cooperation and Development (OECD) is an intergovernmental organization, founded in 1961. Its primary focus is the development of economic growth and trade. The organization acts as *a forum and knowledge hub for data, analysis and best practice in public policy*. OECD publishes a large number of books and guidance documents, primarily with an economic and development focus, but including environmental titles, including the OECD 300 series of biodegradability standards. OECD biodegradability testing was first considered in the mid-twentieth century, and OECD 301 was adopted in 1992.

OECD biodegradability tests are designed to measure the degree and rate at which organic substances are decomposed by microorganisms under controlled conditions. Whilst other biodegradability testing schemes also exist, including ISO, EN, and ASTM standards, the OECD 300 series is the most commonly used and most widely accepted, and is integrated into numerous pieces of legislation. While OECD 301 focuses on screening biodegradability, other OECD tests provide additional information relevant for environmental assessment across other environments, including:

- OECD 301 – Ready biodegradability
- OECD 302 – Inherent biodegradability
- OECD 303 – Simulation of wastewater treatment removal
- OECD 307 – Biodegradation in soil
- OECD 308 – Biodegradation in sediment–water systems
- OECD 309 – Biodegradation in surface water
- OECD 311 – Anaerobic biodegradation

The majority of these tests provide realistic environmental compartment data for specific environment types. OECD 301 determines “ready biodegradability” and is the focus of this work hereafter. The alignment of OECD 301 with other OECD 300 series tests and other biodegradation standards is illustrated in Table 1.

3.2 OECD 301

OECD 301 determines “ready biodegradability”. A substance is classified as readily biodegradable if it meets the following criteria:

- Achieves **≥60% biodegradation** (or ≥70% dissolved organic carbon (DOC) removal)
- Reaches this threshold within a **10-day window** once degradation begins
- Completes the test within **28 days**

These stringent requirements ensure that only substances capable of rapid and extensive biodegradation under non-optimized conditions receive the classification.

[8] BB-REG-NET: Standardised but unfair? S. Walker, R. Rothman, M. Hoseini, J. Vanderhoven, 2025, www.bb-reg-net.org.uk

Table 1: Comparison between OECD 300 series tests and sample ISO and ASTM standards.

Standard	Simulated environment	Suitability	Key output
OCED 301	Aqueous, aerobic, 28 days	Soluble chemicals	Ready biodegradability (pass/fail, curve)
OECD 302	High biomass, aerobic	Difficult-to-degrade chemicals	Inherent biodegradability
OECD 307	Soil	Chemicals, additives	Soil degradation kinetics
OECD 308	Sediment–water	Environmental fate modelling	Compartment-specific half-lives
OECD 309	Surface water	Chemicals	Degradation in natural waters
ISO 14855	Industrial composting	Biodegradable plastics	CO_2 evolution, composting kinetics
ISO 17556	Soil	Plastics	Long-term biodegradation
ISO23977	Marine	Plastics	Degradation in seawater
ASTM D5338	Industrial composting	Plastics	Mineralization rates

3.2.1 OECD 301: Ready Biodegradability Tests

The OECD 301 test consists of six test methods:

- 301A – DOC Die-Away
- 301B – CO_2 Evolution (Modified Sturm Test)
- 301C – Modified MITI (Ministry of International Trade and Industry) (I)
- 301D – Closed Bottle Test
- 301E – Modified OECD Screening Test
- 301F – Manometric Respirometry Test

These tests measure biodegradation based on parameters such as dissolved organic carbon (DOC), oxygen consumption, or carbon dioxide evolution.

3.3 Importance of OECD Tests

3.3.1 Regulatory Importance

OECD biodegradability tests are widely used in: chemical safety regulations, environmental labelling, product stewardship evaluations and compliance with REACH and other international standards.

A "ready biodegradability" designation often supports safer environmental classification and reduces long-term persistence concerns.

3.3.2 Scientific Importance

OECD tests provide a range of data outputs. These data form inputs for environmental modelling and life cycle–based sustainability assessment. OECD 301 outputs include:

- Quantitative biodegradation curves (% degradation vs. time)
- Lag periods before microbial activity begins
- Degradation kinetics under controlled conditions
- Indicators of microbial inhibition

This data has the potential to enable improvements in the accuracy and representativeness of Life Cycle Assessment (LCA) work. The application of data from OECD 301 into LCA will be discussed in the next section.

4 OECD 301 for Plastics

4.1 Limitations of OECD 301 for Plastics

OECD 301 is not specific to plastics and applies to a range of materials. Consequently, when applied to plastics, some specific limitations result. These are in some cases specific to bio-based and biodegradable plastics, and in some cases apply to all plastics.

4.1.1 Solubility

- Lack of solubility requirements: Plastics are typically solid and insoluble, preventing effective contact with microorganisms.
- No surface-area adjustment: Plastics degrade via surface erosion, but OECD 301 assumes uniform solubility.

4.1.2 Test conditions

- Inappropriate test temperature: Biodegradable plastics often require elevated temperatures (e.g., 58°C for PLA), which are not provided in OECD 301.
- Short duration: The 28-day test period is insufficient to observe meaningful polymer degradation.
- Limited relevance to real environments: Plastics degrade differently in compost, soil, marine systems, and anaerobic conditions.

Specific limitations related to the use of OECD 301 data in LCA are highlighted in Section 5.2

4.2 Data gaps in OECD 301 for Plastics

Further to these limitations, a series of data gaps in OECD 301 when applied to plastics have been identified. These apply to non-polymer materials in some cases but are primarily plastic specific.

- Polymer-specific degradation kinetics (hydrolysis rates, molecular weight loss) are not captured.
- Lack of information on erosion mechanisms and fragmentation.
- Absence of conversion of polymer carbon to CO_2 under realistic conditions.
- No identification of microplastic formation or intermediate oligomers.
- No environmental compartment behaviour: soil, compost, marine and anaerobic behaviour must come from other standards (ISO 14855, ISO 17556, ASTM methods).

These limitations and gaps do limit the quality of results achievable when applying OECD 301 to plastics, including bio-based and biodegradable plastics. Further challenges of applying the method to polymers in liquid formulation (PLFs) have also been highlighted[9]. However, OECD 301 testing is still able to provide useful information on the degradation of materials and can still support the development of LCA of these materials. Subsequent sections of this work will focus on the application of OECD 301 to Life Cycle Assessment.

[9] Beyond the guidelines: rethinking OECD biodegradability testing for polymers in liquid formulations, Frank Stott, Edisa García Hernández, Jessica Staniland, Amy Goddard, Sarah Davidson, Ian Tooley, DOI https://doi.org/10.1039/D5SU00669D

5 Application of OECD 301 data to Life Cycle Assessment

Integrating results of OECD biodegradability testing into LCA requires the translation of laboratory observations into parameters suitable for environmental fate and impact models. ISO 14040 series guidance depicts the LCA process as four interconnected sections: Goal and scope definition, Inventory analysis, Impact assessment and Interpretation (Figure 3).

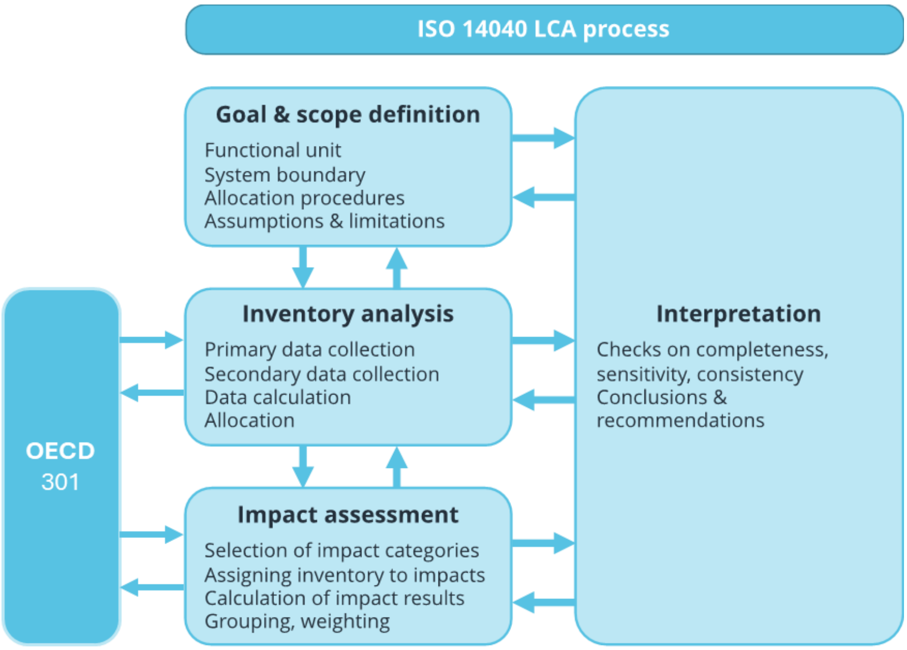

Figure 3: Primary interaction between OECD 301 data and the four key steps of the LCA process (adapted from ISO 14040)

The integration of OECD data into LCA can occur at any of the four steps in the LCA process, but primarily occurs in the life cycle inventory (LCI) phase and the life cycle impact assessment (LCIA) phase.

Subsequent sections highlight the current and potential future application of OECD 301 data in LCA.

5.1 Use of OECD 301 data in Life Cycle Assessment

As highlighted, the main areas in which OECD data can be applied in LCA are the Life Cycle Inventory (LCI) and Life Cycle Impact Assessment (LCIA) phases. Key areas in which OECD data is currently used in the Life Cycle Inventory (LCI) phase of LCA for BB-Materials include:

- Extracting kinetic parameters: rate constant (k), lag phase duration, and extent of biodegradation.
- Determining the degraded vs. persistent fraction for relevant environmental pathways.
- Allocating emissions to appropriate environmental compartments (air, water, soil, sediment).
- Accounting for biodegradation byproducts, such as CO_2 or CH_4.

The integration of these data into LCA is not arbitrary and requires LCA practitioners with expertise in adapting and developing datasets.

In the Life Cycle Impact Assessment (LCIA) phase, OECD data is most commonly used for the calculation of impact categories. In this application, biodegradation parameters from OECD testing can be used in the calculation of several impact categories, such as:

- Freshwater and marine ecotoxicity
- Human toxicity
- Climate change (via CO_2 and CH_4 release)
- Environmental persistence

Impact assessment methods such as USEtox, TRACI, and ReCiPe require input data such as degradation half-lives, partition coefficients, and bioavailability data, some of which can be derived or approximated using OECD test outputs.

As highlighted in previous work on the BB-REG-NET project[10], new impact categories are required to enable the fair comparison of fossil and BB-Materials. As the Seven Steps to Fairness report highlighted, and as shown in Figure 4, these impact categories require additional data. This data can, to a large extent, be captured from testing such as that in the OECD method.

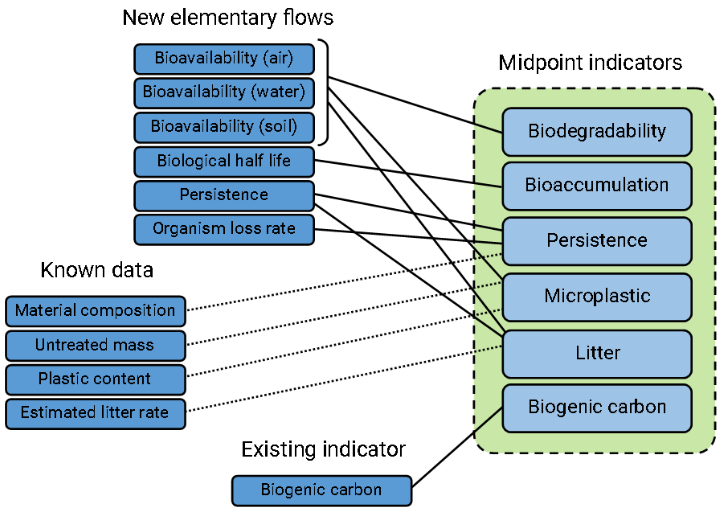

Figure 4: Proposed additional midpoint indicators for comparison of fossil and BB materials (right), and requisite data from new elementary flows, known data, and existing indicator (left). From Seven Steps to Fairness report.[9]

Table 2 describes the data required for each of the recommended impact categories and highlights potential data sources or proposed calculation methodologies. OECD 301 testing data can contribute to all proposed new impact categories (excluding biogenic carbon, since this is already calculated).

Table 2: Data collection required to support proposed impact categories. From Seven Steps to Fairness report.

Impact category	Data type	Proposed collection methodology
Biodegradability	Bioavailability	Experimental measurement or collation of existing data on bioavailability to ascertain required elementary flows for bioavailability calculation
Bioaccumulation	Biological half-life (substances)	Collation of existing measurements of biological half-life of common substances
	Loss rate (organisms)	Collation of existing loss rate information for organism classes (e.g. mammalian, aquatic, avian)
Persistence	Compound persistence	Use of existing persistence data and collation of elementary flows required to calculate persistence
Microplastic formation	Bioavailability	As above
	Plastic content of material types	User input or estimation through PLEX methodology
Biodiversity impact	No new data needed	Use of existing data and land use biodiversity method from Chaudhary et al to develop biodiversity calculation through existing elementary flows
Litter	Estimated litter rates	User input or estimation through PLEX methodology
Global warming potential (biogenic)	No new data needed	Use of IPCC method with separate biogenic and fossil carbon impact categories

[10] BB-REG-NET: Seven Steps to Fairness. S. Walker, R. Rothman, A. Newman, J. Vanderhoven, 2026, www.bb-reg-net.org.uk

5.2 Limitations in the applicability of OECD 301 data in LCA

A critical limitation on the integration of OECD data into LCA is the use in testing of idealised conditions. OECD 301 tests represent data from laboratory conditions, which can differ significantly from real environments in a range of ways. Laboratory testing is likely to provide:

- Constant temperature
- Well-mixed aqueous phase
- High oxygen availability
- Controlled inoculum source

These attributes may not apply, therefore limiting the applicability of OECD 301 data to LCIA calculations. To address these limitations, additional data or extrapolation is often required in order to model environmental compartments accurately.

5.2.1 Data gaps and missing information

Although OECD tests provide valuable insights, several critical data gaps limit the applicability of OECD 301 data in the robust support of LCA modelling. Four key data gaps have been identified:

- Lack of degradation product identification: OECD tests measure mineralization but do not indicate which intermediates form.
- Absence of compartment-specific half-lives: Environmental conditions (soil, sediment, marine water) differ from test settings.
- Limited test duration: OECD 301 covers 28 days, while environmental degradation may take months or years.
- Simplified conditions: Real environments include variations in temperature, nutrient availability, microbial diversity, and mixing.

5.2.2 Additional Data Required for LCA

The four key data gaps identified above can be at least partially mitigated through the collection of additional data. The collection of this data would enable more trust to be placed in the results of LCA studies supported by data from OECD 301 testing. However, it should be noted that even without this additional data, the use of OECD 301 testing data to provide product specific information for LCA is a positive step and is likely to yield LCA results of with greater specificity than those achieved using only generic or database data. In all cases, appropriate sensitivity and uncertainty analysis should be undertaken, and results should be presented with suitable quantitative and qualitative descriptions of accuracy.

Additional data which would help reduce the impact of data gaps in OECD 301 data when used to support LCA include:

- Partition coefficients (Kow[11], Koc[12], Henry's constant[13])
- Environmental half-lives in multiple compartments
- Bioaccumulation data (BCF[14]/BMF[15])
- Toxicity data (EC50[16], NOEC[17], LC50[18], etc.)
- Emission scenario definitions (quantities, timing, and pathways)
- Transformation product toxicity and persistence

[11] Octanol-water partition coefficient. How a chemical distributes between octanol and water. Octanol simulates fatty tissue, so the ratio indicates the level of lipophilic tendency of the material, thus indicating the likelihood of bioaccumulation potential.
[12] Organic carbon partition coefficient. A measurement of a chemical's tendency to adsorb onto organic matter, predicting organism uptake into soil or sediment.
[13] Relates the proportion of a chemical in the water phase to that in the air phase, giving an indication of the likelihood of the chemical evaporating.
[14] Bioconcentration factor.
[15] Biomagnification factor.
[16] Half maximal effective concentration.
[17] No Observed Effect Concentration: The highest concentration of a substance at which no adverse effects are observed in a specific test organism.
[18] Median lethal concentration of a chemical that can cause death in 50% of the population exposed to it for a specific duration and observed for a specified period of time.

Any additional data is positive in improving the accuracy of LCA, but without these parameters, impact assessments (particularly in areas such as ecotoxicity and human health) remain incomplete or inaccurate. This does not necessarily mean results should not be presented, but emphasises the need for careful handling of results and clear and transparent descriptions of uncertainty.

6 Summary and Recommendations

Life Cycle Assessment (LCA) is a standardised method used to evaluate the environmental impacts of a product, process, or service across its entire life cycle, from raw material extraction through production and use to end-of-life. Widely used to inform sustainable decision-making, LCA plays an important role in comparing the environmental performance of different materials and technologies. However, LCAs can contain methodological biases, including those affecting both fossil-based and bio-based materials. In particular, biodegradability and end-of-life environmental fate are often not well represented as impact categories, meaning potential benefits or trade-offs associated with biodegradation may be overlooked.

The OECD 300 series of biodegradability tests are designed to measure the extent and rate at which organic substances are broken down by microorganisms under controlled laboratory conditions. While these methods have limitations, data gaps, and challenges in applicability, they still provide useful information, particularly the OECD 301 "ready biodegradability" test.

Their relevance to plastics is subject to additional constraints, including the relatively short test timescales, limited insight into degradation kinetics, and other methodological factors that may not fully capture real-world behaviour.

Applying data from OECD biodegradability testing within Life Cycle Assessment (LCA) provides an opportunity to move beyond generic studies based on database averages or assumptions toward more product-specific analysis. However, because OECD 301 testing conditions do not entirely reflect real-world environments, the resulting data may not always be fully representative when used directly in LCA. Despite this, OECD 301 results are often more product-specific than the generic data commonly used, and when applied appropriately can improve the representativeness of LCA modelling.

In summary, OECD 301 does not provide perfect data or fully resolve all LCA challenges. Nevertheless, it offers a valuable opportunity to incorporate product-specific biodegradation information into LCAs and improve the representation of degradation processes for bio-based materials. This, in turn, can support the development of more appropriate end-of-life modelling approaches and the evolution of new impact categories, enabling better representation of biodegradability within LCA.

From an end-of-life perspective, data relevant to real life degradation conditions would be ideal for LCA. Future research should concentrate on collecting such data, including degradation products released to air and soil.

Recommendations

We offer five recommendations related to the use of OECD 301 data for LCA practitioners undertaking comparative LCA of fossil and bio-based or biodegradable materials:

- Use OECD 301 data in LCA where possible and relevant.
- Be aware of the limitations of OECD 301 data, particularly related to laboratory versus real world conditions.
- Collect and calculate supporting information to bridge gaps in OECD 301 and LCA data and improve representativeness.
- Present information transparently and with appropriate sensitivity and uncertainty analysis.
- Continue to move towards fair comparison between fossil and bio-based materials by adopting the seven impact categories highlighted in a previous report; namely, Biodegradability, Bioaccumulation, Persistence, Microplastic formation, Biodiversity impact, Litter, Global warming potential (biogenic) - supported by OECD 301 data where available.