Advancing Fate Assessment:

Integrating Biodegradation and Toxicity Testing

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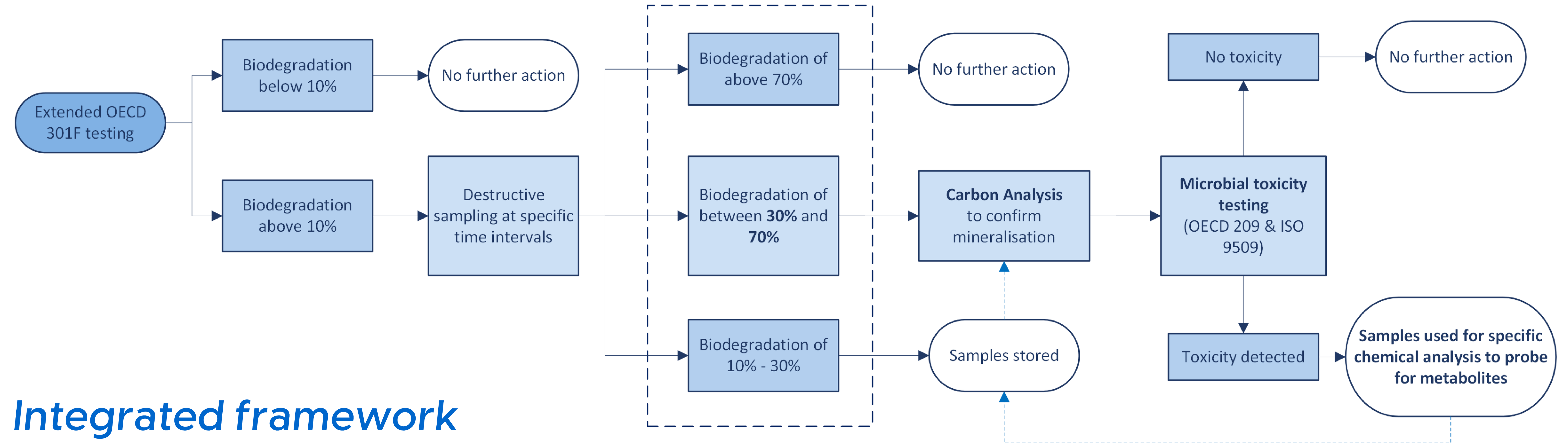
Introduction

- Biodegradation screening tests underpin chemical persistence assessment and are widely used to inform **environmental fate**, **exposure**, and **risk** evaluation; however, most focus on **mineralisation** as an indicator of degradation, providing limited insight into transformation pathways or intermediate products formed.
- For complex and slowly degrading substances, including some polymers, this represents a critical knowledge gap, as **diverse metabolites** may be formed, with properties and hazard profiles distinct from those of the parent material, and mineralisation alone may provide an incomplete basis for **environmental safety assessment**.
- The proposed framework links **biodegradation kinetics**, **metabolite characterisation**, and **microbial toxicity** to support more informative and decision-relevant fate assessment. For many chemicals, including some polymers, specific chemical analysis is technically challenging and resource-intensive. By using biodegradation outcomes to inform **targeted** chemical analysis, analytical effort is focused where metabolites and transformation products are **most likely** to be present.



Integrated framework

The proposed testing framework integrates biodegradation and microbial toxicity testing. A biodegradation threshold of **10%** triggers **destructive sampling** (e.g. OECD 301 kinetics; OECD 308 metabolite thresholds). Thresholds for sampling are independent of time. Priority for **metabolite characterisation** is given to samples with **30% - 70%** biodegradation, due to the higher likelihood of potential metabolites, with substantial remaining organic carbon. At **70%** biodegradation, limited remaining parent material and a low level of metabolites is assumed. Residual carbon can be used as a surrogate for potential exposure to non-mineralised material, particularly for polymers. Microbial toxicity and chemical analysis are only triggered when informative, using **sequential analysis** of stored samples.

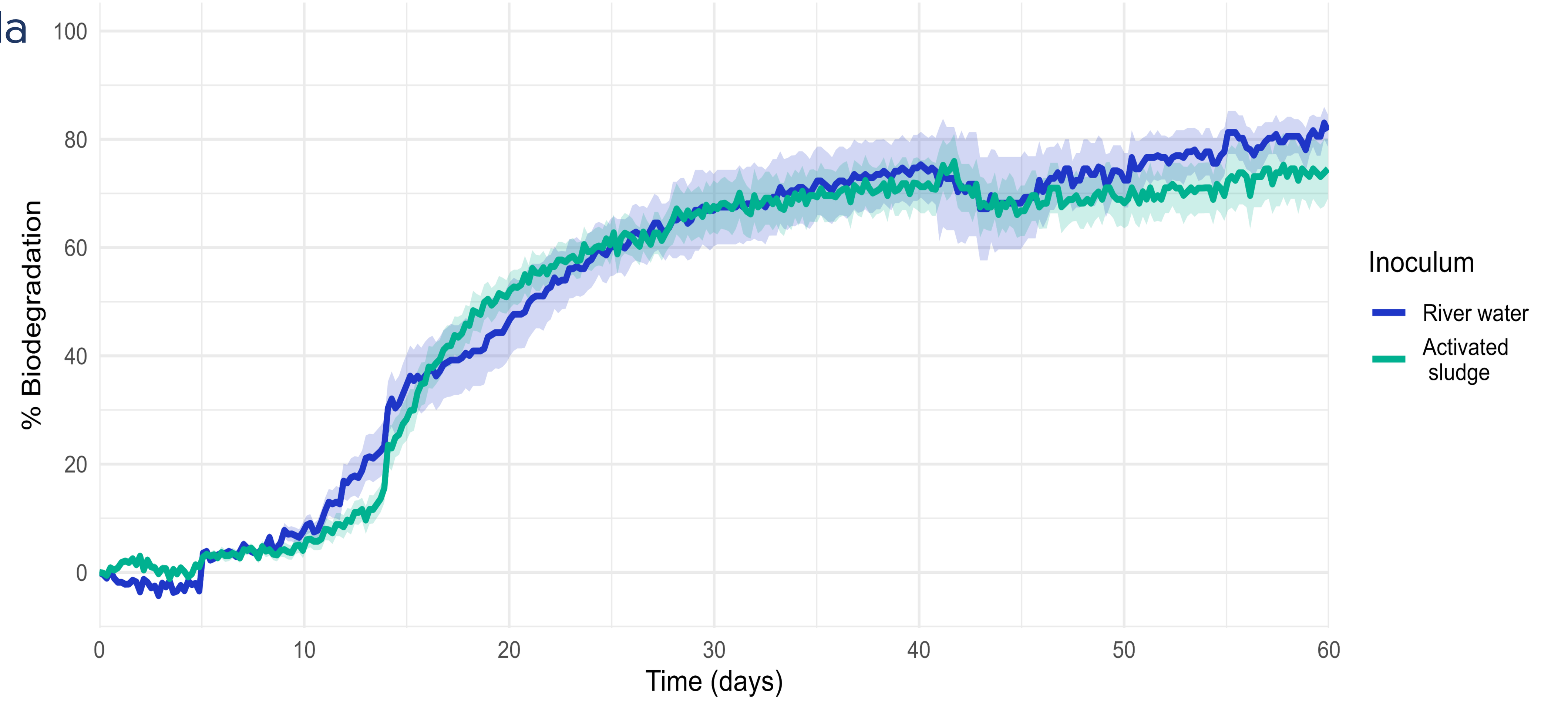
Case Study: Poly(vinyl alcohol)

A poly(vinyl alcohol) (**PVOH**) (130kDa), a widely used water-soluble polymer, was used as a case study. An extended OECD **301F** test approach was used. Slower degradation enabled **repeated destructive sampling** every 2 weeks, to measure Total Organic Carbon (**TOC**), and allowing future targeted chemical analysis to explore potential transformation products, and review of microbial toxicity.

Tests were conducted in **activated sludge** to represent a standard screening matrix, and in **river water** to capture slower degradation kinetics, and increase the likelihood of observing intermediate metabolites. There was **no microbial toxicity** (OECD 209 & ISO 9509) detected, up to 1000 mg/L of this PVOH.

Future work will focus on **further testing** of the proposed framework, with additional chemicals and chemical analysis of metabolites.

1a



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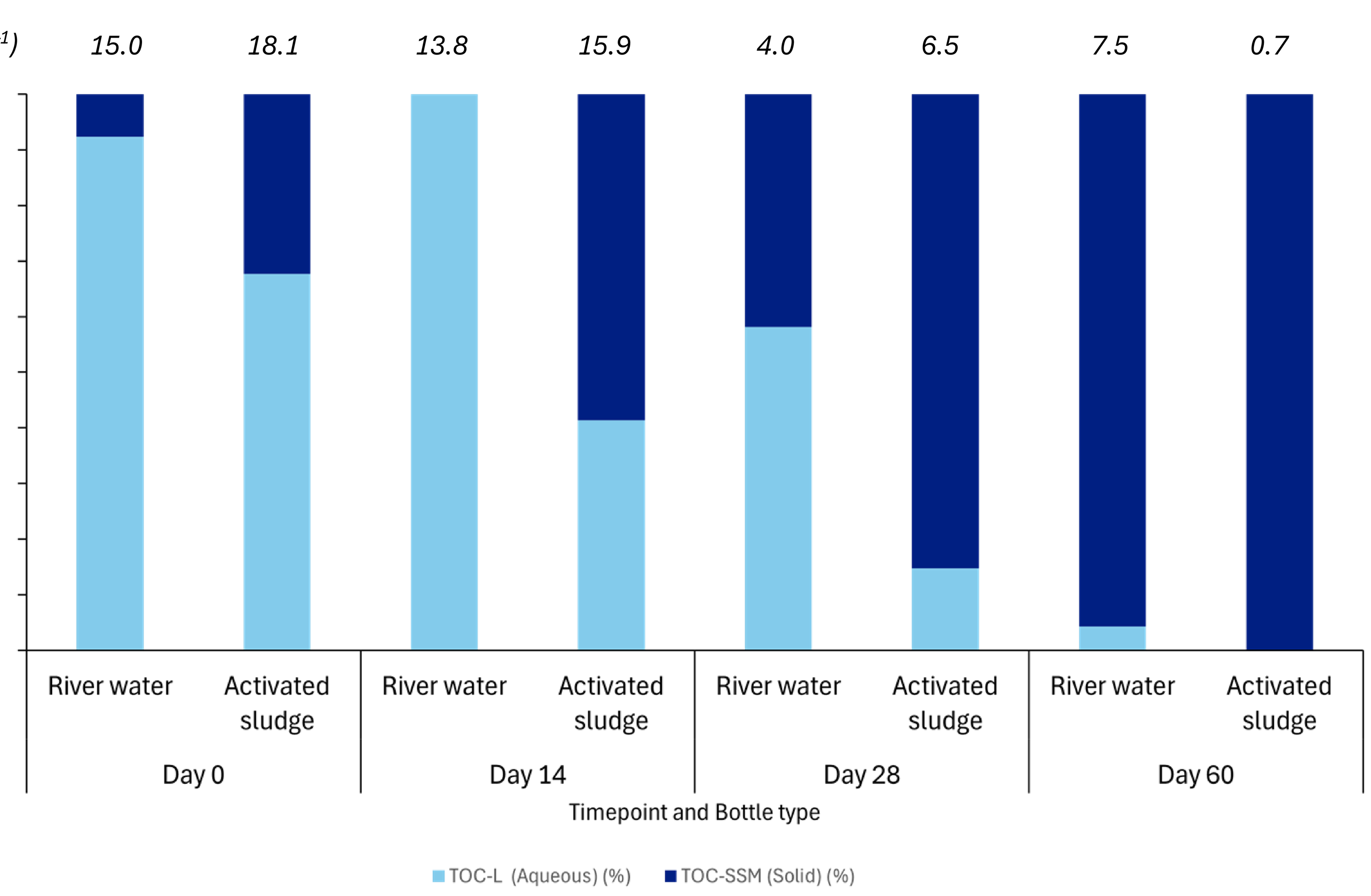

Figure 1 (a) The biodegradation of this PVOH over 60 days in an adapted extended OECD 310F test, in river water and activated sludge. **(b)** Stacked bar chart showing which fraction (aqueous (light blue) or solid (navy)) of destructive samples contained carbon, at 4 timepoints, in river water and activated sludge, with total amount TOC (mgL^{-1}). At the start of the study, carbon is mostly found in the aqueous phase. Later in the study, more carbon is found in the solids.

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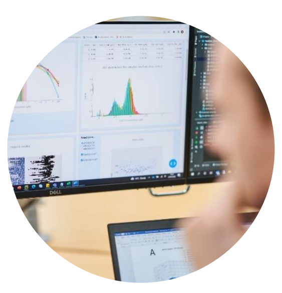

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