Assessing the Biodegradability of Water-Soluble Polymers:

Scientific and Regulatory Perspectives for Safe and Sustainable by Design Innovation

Katie Endersby[1], **Jayne Roberts**[1], **Chris Finnegan**[1]
[1] *Safety, Environment & Regulatory Science (SERS), Unilever*

Introduction

Water-soluble polymers (**WSPs**) are widely used in home and personal care. However, their environmental fate - particularly **biodegradability** - remains poorly characterised. Current OECD and ISO biodegradability tests were developed for low molecular weight chemicals and often underestimate the degradability of WSPs due to factors like **high molecular weight**, **charge density**, and **limited bioavailability**.

This framework proposes integrating empirical, mechanistic and predictive approaches to support more robust and proportionate persistence assessments. Grouping WSPs allows for **collective assessment of polymers** based on shared features. This will allow identification of **persistent** and **non-persistent** substances, while still enabling innovation in **safe and sustainable polymer design**.

Tiered framework

This **framework** gives a structured approach to **understand persistence** for WSPs within existing regulatory paradigms.

WSPs require enhanced application of standard frameworks, including **modified** and **extended** biodegradability testing, e.g. increased test duration or biomass.

The work recognises that a single CAS number can currently encompass polymers with different molecular weights, and environmental behaviours, which can complicate interpretation of biodegradability data.

This **hypothesis-led** approach uses **evidence built progressively** across the tiers, integrating a chemical's properties, exposure context, and mechanisms of biodegradation. Progression through the tiers is driven by indications of potential persistence, which supports scientifically robust interpretation.

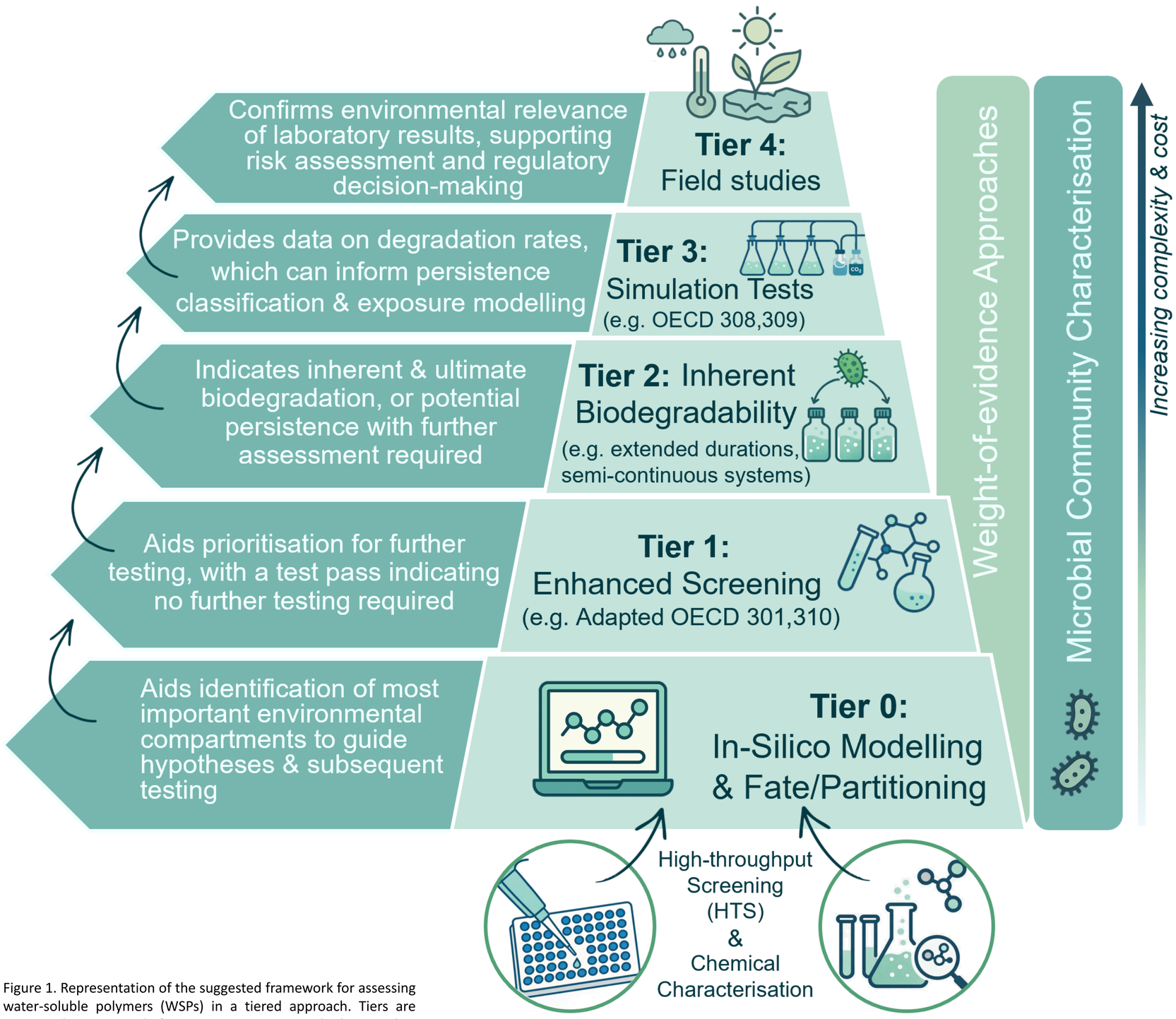

Figure 1. Representation of the suggested framework for assessing water-soluble polymers (WSPs) in a tiered approach. Tiers are presented in a pyramid of increasing environmental relevance, but also increasing complexity, resource requirements, and cost.

Future perspectives

High-throughput screening (**HTS**) is one way to prioritise polymer structures for further testing. Also, **microbial community profiling** can strengthen test reproducibility and explain variability in outcomes, but is still challenging to carry out alongside testing a standardised manner. While current **in silico** tools can fall short for polymers, emerging approaches like BIGSMILES and Polymer Genome are starting to address this limitation. Together, these tools can support a **weight-of-evidence approach** grounded in overall persistence, enabling more proportionate, science-led decisions.

Conclusions

This work suggests that persistence assessment for water-soluble polymers requires a **mechanistically informed**, **tiered** approach rather than reliance on single biodegradability end-points. By integrating **degradation mechanisms**, **exposure context**, and **weight-of-evidence interpretation**, the framework supports realistic and proportionate regulatory decision-making, within existing regulatory paradigms.

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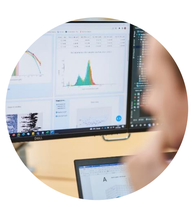

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