Table S1: Overview of typical OECD and ISO test methods relevant to the fate assessment of crosslinked synthetic superabsorbent polymers (SAPs) in soil and their current main limitations when applied, including limited extractability, non-extractable residue (NER) formation, altered soil-water interactions, and the difficulty of distinguishing between physical sequestration, transformation, and true microbial mineralization

Test	Primary endpoint(s) measured	Key underlying assumption(s)	SAP-specific limitation(s)	Principal interpretation challenge
OECD 307 Soil Transformation Test (2002)	Parent-substance decline, transformation products, CO_2 evolution, NERs, degradation half-lives (DT_{50}/DT_{90})	Test substance remains extractable, analytically accessible, homogeneously distributed, and amenable to mass-balance calculations	Crosslinked SAPs swell rather than dissolve; extractability decreases over time due to cation bridging, aggregate incorporation, organo-mineral association, and NER formation; parent polymer often difficult to quantify directly	Declining recoveries may reflect sequestration or reduced extractability rather than true degradation; difficult distinction between transformation, persistence, and analytical disappearance
OECD 301B / 301F Ready Biodegradability Tests (1992)	CO_2 evolution (301B) or O_2 consumption (301F) in aqueous systems	Substance is dissolved or uniformly dispersed and readily bioavailable; theoretical oxygen demand can be calculated	Crosslinked SAPs swell rather than dissolve; environmental exposure conditions poorly represented; only ultimate mineralization assessed	No information on fragmentation, functional deterioration, transformation products, bound residues, or persistence of residual polymer fractions
OECD 106 Adsorption/Desorption Test (2000)	Sorption coefficients (K_d, K_{oc}), adsorption-desorption behavior	Dissolved substance reaches equilibrium partitioning between soil and solution phase	SAPs form hydrated gel phases and act as additional sorptive compartments; physical entrapment and swelling dominate behavior	Physical immobilization may be interpreted as sorption; conventional K_d/K_{oc} concepts may not adequately describe SAP-soil interactions
OECD 312 Leaching/Percolation Test (2004)	Mobility and transport through soil columns	Substance remains dissolved and is transported via percolating soil water	SAPs retain water, alter hydraulic conductivity, and become physically retained within soil pores; mobility governed by particle retention rather than solute transport	Reduced mobility may result from hydrogel retention rather than chemical sorption or degradation; leaching behavior difficult to compare with conventional chemicals
OECD 216 Soil Nitrogen Transformation Test (2000)	Effects on ammonification and N transformation processes	Changes in microbial activity reflect effects of the test substance on soil functioning	SAPs strongly modify water availability, oxygen status, and nutrient diffusion, indirectly affecting microbial processes	Observed effects may result from altered soil moisture conditions rather than direct transformation of SAP-C

Test	Primary endpoint(s) measured	Key underlying assumption(s)	SAP-specific limitation(s)	Principal interpretation challenge
OECD 217 Soil Carbon Transformation Test (2000)	Soil respiration and microbial C transformation activity	Changes in respiration reflect effects of the test substance on microbial activity	SAPs influence water retention, aeration, substrate accessibility, and microbial habitat conditions	Increased or decreased respiration cannot be directly linked to SAP degradation; strong potential for priming and indirect moisture effects
ISO 17556 Soil Biodegradation Test (2019)	CO_2 evolution and/or O_2 consumption as indicators of ultimate aerobic biodegradation	SAP is homogeneously distributed, bioavailable, and accessible to microorganisms	SAPs occur as heterogeneous hydrogel phases with restricted microbial accessibility; swelling alters soil aeration, moisture, and microbial activity; NERs not quantified	Increased respiration cannot distinguish polymer mineralization from priming effects, microbial turnover, or native SOM mineralization without isotope tracing