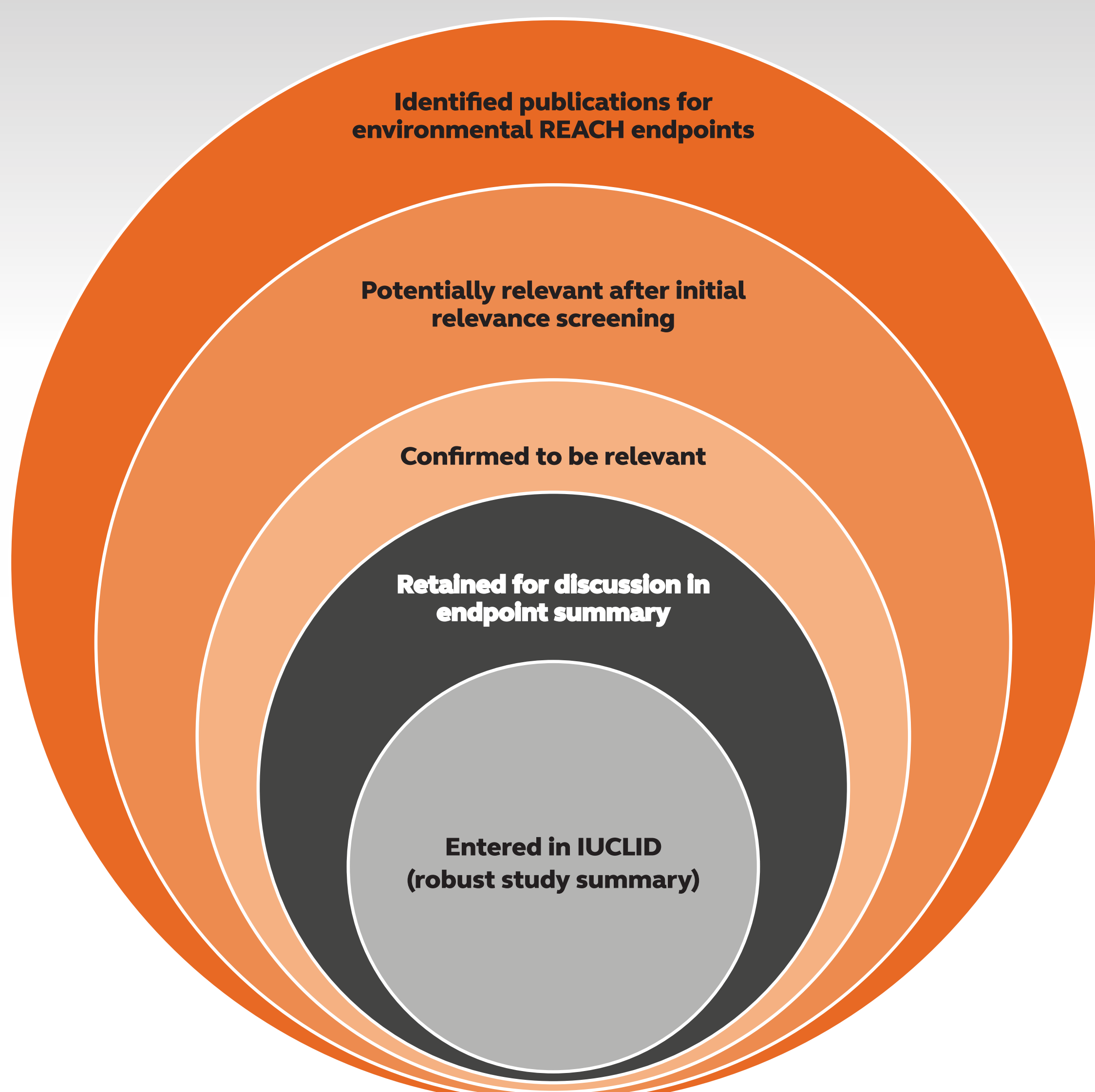


Environmental fate of CeO₂ nanoparticles

Critical evaluation of available data and implications for exposure assessment

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Methods

- Literature search → > 900 publications
- Initial relevance screening → ca. 450 publications retained
- Combination of sources in weight-of-evidence (WoE) approach that best reflects the findings on the endpoint under consideration → IUCLID entries (robust study summaries)
- After relevance confirmation → inclusion in xls table: information on nanoparticles tested, materials and methods, key results and findings → inclusion as Annex in REACH dossier for reasons of completeness
- Additional set of sources not retained for the WoE approach but delivering important additional information on the endpoint is not entered in IUCLID but only discussed in the endpoint summary
- Screening against criteria for assessing reliability (based on OECD recommendations where available)

Results Results for uncoated, non-surface treated, mainly spherical nanoparticles

Dispersion Stability
14 studies - 13 WoE

Dissolution of Ce from CeO₂ NPs in natural waters negligible

Rapid removal of CeO₂ NPs from natural waters through homo- or hetero-aggregation and consequent sedimentation

Stability of dispersions of CeO₂ NPs in natural waters increases with decreasing ionic strength, decreasing pH, increasing natural organic matter and decreasing amounts of suspended solids or natural colloids

Sediment is most important 'sink' for CeO₂ NPs

Adsorption / Retention
22 studies - 16 WoE

For CeO₂ NPs, log K_d values obtained (2.3-5.0 L/kg) very similar to log K_d values for dissolved Ce (50th pct = 3.54 L/kg)

Methodology challenged for CeO₂ NPs → does not distinguish between sorption, precipitation, solid-state diffusion, etc.

K_r concept for soil retention developed by Cornelis et al. (2010, 2011, 2012) – focus on NP retention (ultrafiltration added)

Log K_r values are typically significantly lower than log K_d values for dissolved Ce

Adsorption is less relevant for e-fate of CeO₂ NPs than aggregation

Nevertheless, major portion of CeO₂ NPs remains immobile in soil in aggregated form

In WWTPs overall significant removal observed, up to 10% reported to stay in liquid phase

Majority ending up in biosolids → possible pathway for introduction to soil via biosolid application in agriculture

Bioaccumulation
Aquatic: 32 studies - 10 WoE
Terrestrial: 106 studies – 11 WoE

Experimental distinction between Ce and CeO₂ NPs and between actual uptake and adsorption needed to get a clear view on bioaccumulation of CeO₂ NPs

CeO₂ NPs in aquatic invertebrates and fish are mainly found in skin, gills, intestines, etc. with no substantial absorption through the gastrointestinal epithelium

As for dissolved Ce for BCF/BAF → decreasing BCF/BAFs with increasing trophic level, BCF/BAF for fish – certainly after gut clearance – is low (as a reference: key BCF/BAF for dissolved Ce in fish is 16 L/kg ww)

In terrestrial invertebrates, BSAFs were << 1 and no enrichment was observed. No substantial absorption through skin or gastrointestinal absorption was observed

In plants, BSAFs were << 1 and no enrichment was observed; there is some evidence of penetration through root barriers and other tissues. BSAF for roots is typically higher than for aboveground parts. Translocation to aboveground plant parts is limited (TF < 1)

No evidence for CeO₂ biomagnification in aquatic, aquatic-sediment or terrestrial foodchains (TTF < 1)

Implications for exposure and risk assessment

- Any (eco)toxicological effects seem to be particle-related (see our other POSTER*)
- Exposure (and risk) assessment needs to be CeO₂ NP-based, not Ce-based
- Necessary parameters are not always readily available
 - unharmonised testing methodology for NPs
 - mismatch between input parameters of exposure models and REACH endpoints

Take home messages

- Negligible dissolution of Ce from CeO₂ NPs.
- In natural waters, CeO₂ NPs will partition to sediment, which represents the most important 'sink' in the aquatic compartment.
- In WWTPs, most of the CeO₂ NPs will end up in biosolids, which could represent a source for CeO₂ NPs in agricultural soil in case of biosolids application.
- CeO₂ NPs in soil typically occur as aggregates which are not very mobile. Actual adsorption is limited.
- Bioaccumulation potential in aquatic and terrestrial organisms is low and there is no evidence for biomagnification.

* Deleebeek N, Claessens M, Lefèvre L, Mandrillon AL (2022). Environmental hazard assessment of CeO₂ nanoparticles - How to evaluate the huge amount of available ecotoxicological data in a transparent way for regulatory purposes. Poster presented at SETAC Europe 32nd Annual Meeting, Copenhagen, Denmark.