USING EXISTING RESOURCES FOR SILICA NANO MATERIALS ENVIRONMENTAL HAZARD ASSESSMENT - SPECIES SENSITIVITY DISTRIBUTION (SSD) MODELLING, IN THE FRAME OF SABYNA PROJECT

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BACKGROUND

"Implementation of nanotechnology in new products is occurring at a rapid pace."

Ensuring that innovative nano-enabled products are safe and sustainable for human and environmental health has become a **priority** for the **European Commission** and a **challenge** for **industries** to comply with the recommended frameworks. The **SAbyNA project (H2020-NMBP-15-2020)** was developed with the main aim to produce a Guidance Platform for the industries to eventually implement safe-by-design (SbD) more efficiently and cost-effectively. An important tool to predict the ecological risk from existing data to classify hazards of substances and chemicals in the Species Sensitivity distribution model (SSDs). Despite its extensive use and detection in the environment, SSD models for aquatic and terrestrial species of synthetic amorphous silicon dioxide nanomaterials (SiO_2 NM) is not provided by the European Chemical Agency.

OBJECTIVE

Use of SSDs as a categorizing system for environmental impact assessment of SiO_2 NM.

METHODS

A series of criteria was used for data selection (Fig 1) from previously published literature on SiO_2 NM ecotoxicology within freshwater and terrestrial environments. Data points were converted to long-term NOEC values using an assessment factor approach, after which the SSD model was plotted to provide a probabilistic estimation of the toxicity threshold, ranking each species-derived threshold concentration and considering the 5th percentile (HC_5) of this distribution to be the safe threshold concentration to be then used for hazard classification according to difference sources (Table 1) .

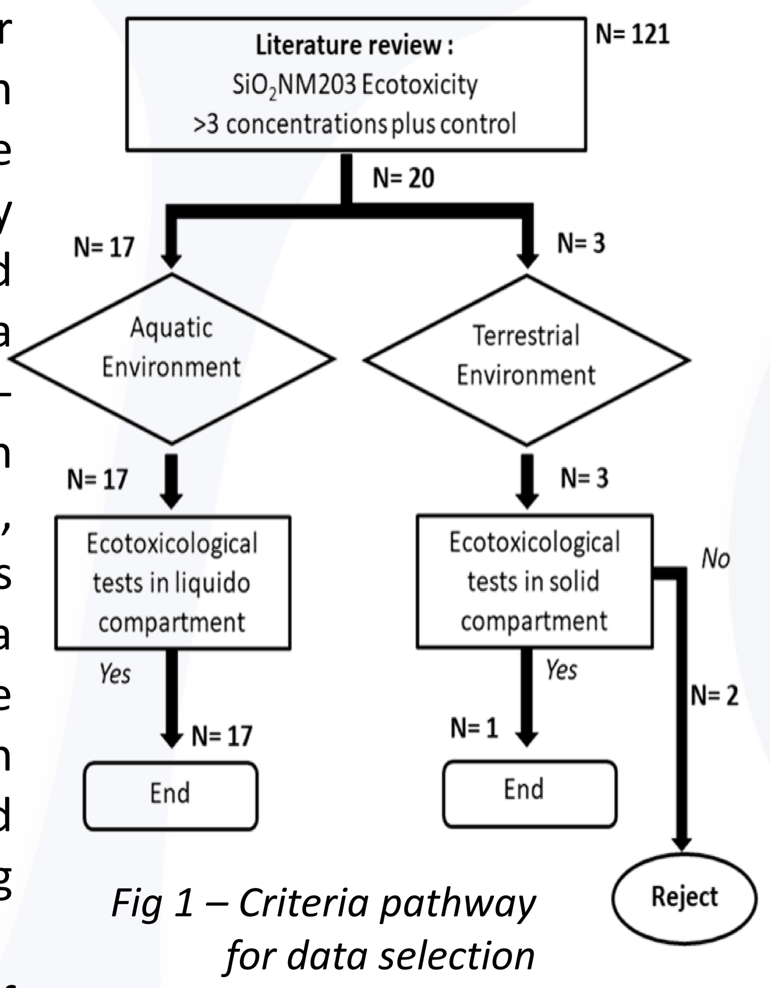


Fig 1 – Criteria pathway for data selection

Table 1 - Existing hazard toxicity thresholds adapted for SAbyNa project for soil and freshwater species. PBT - persistent, bioaccumulative and toxic; vPvB - very persistent and very bioaccumulative; MNM - manufactured nanomaterials

	Effect	Very toxic	Toxic	Harmful	Units	Contaminant type	Source
Terrestrial species (macro-organisms)	Longterm-NOEC [Acute]	≤ 0.1	≤ 1	≤ 10	mg/Kg	PBT & vPvB#	1-3
	Longterm-NOEC [Chronic]	≤ 0.1	> 0.1 & ≤ 1	> 1 & ≤ 10	mg/Kg		
Freshwater species	Longterm-NOEC [Chronic]*	<2.5	2.5-12.5	12.5-50	mg/L	MNM	4
		< 0.1	0.1-1	(-)	mg/L		5-6

no values for MNM; *no values for acute

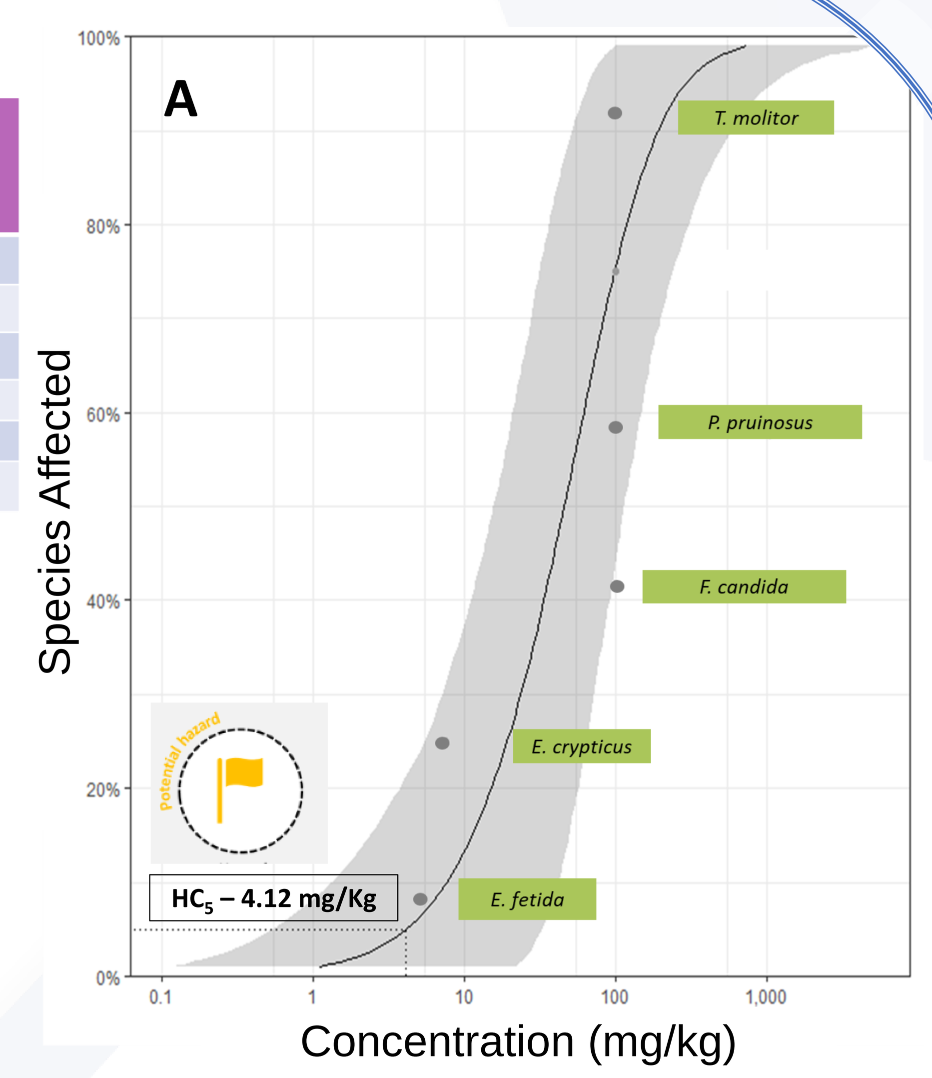
References: 1- Hartmann *et al* 2014; 2 - UN 2006; 3- Scholz-Starke *et al* 2020; 4 - Hansen *et al* 2014; 5 - ECHA 2013

RESULTS

Table 2 - Number of SiO_2NM toxicity data points derived from the literature split by species criteria used for SSD.

SiO_2NM	Endpoints	Microbial/ Protozoa	Algae	Invertebrate	Plant	Vertebrate
(Aquatic) FreshWater	Growth	2	65		2	
	Mortality	4	12	12		16
	Development					28
	Behavioural					8
	Biomarkers		5			1
Terrestrial	Behavioural			6		

A database of 161 toxicity data points for SiO_2 NM (Table 2) from 18 different species, 5 terrestrial (2 phylum) and 13 freshwater (7 phylum) was generated. The majority of the collected data corresponded to acute toxicity test, making up 91% of all data points. Furthermore, the 9% of data corresponding to chronic exposure were only available for freshwater species. Data was found for only 5 terrestrial invertebrate species.



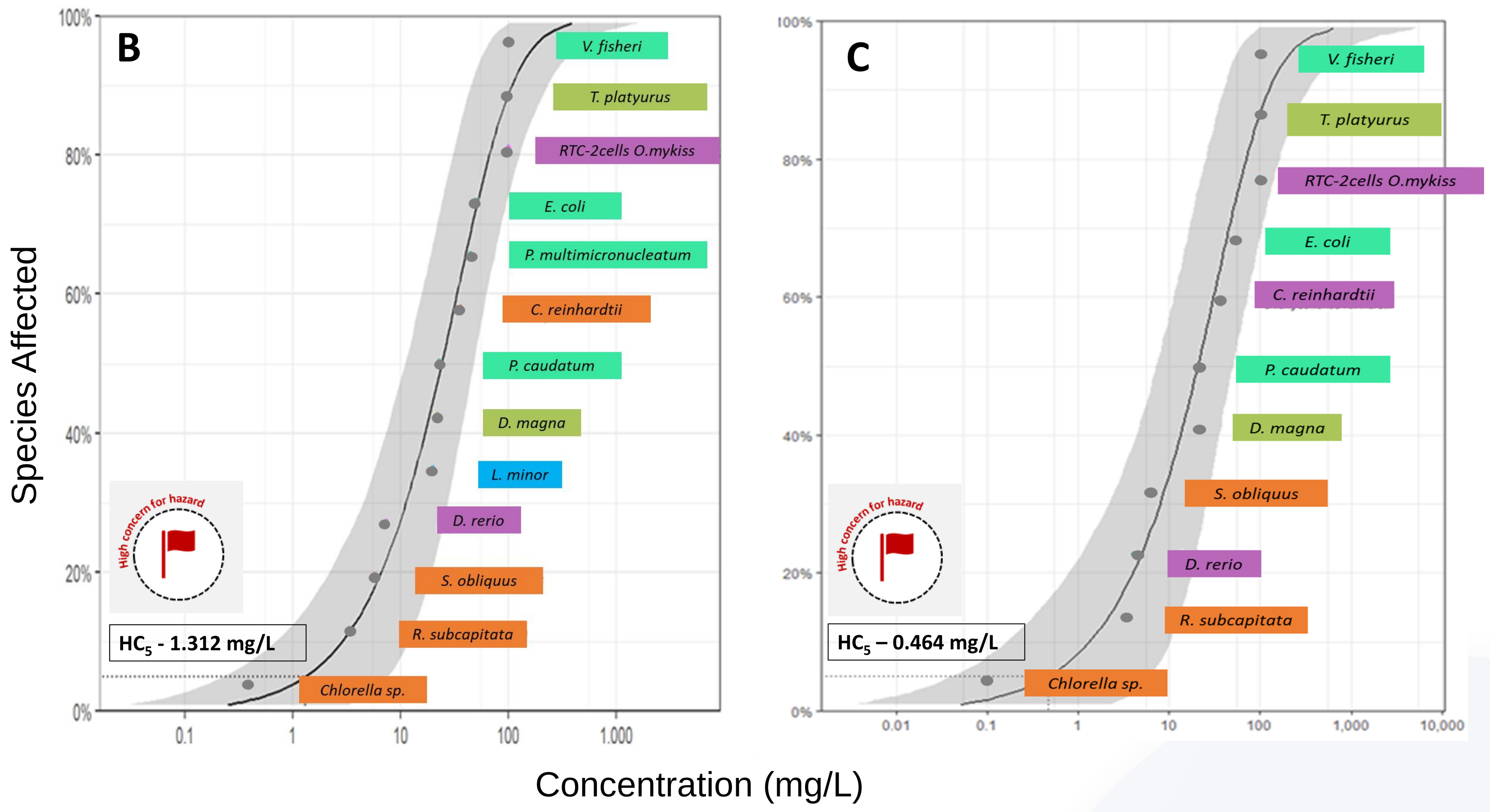


Fig 2- Species sensitivity distribution (SSD) plots of SiO_2 NM for terrestrial (A) and freshwater species (B and C). B- fitting acute+chronic toxicity data; C- fitting only acute toxicity data endpoints. Extrapolated HC_5 value and corresponding hazard flag classification are given for each plot.

Very little data is available for terrestrial toxicity exposure to SiO_2 NM. Data was obtained from five species, giving a **HC_5** value of **4.12 mg/kg** and flagged yellow (Fig 2A), according to threshold sources in table 2, with the red worm *E. fetida* plotted as the most sensitive species and the mealworm *T. molitor* as the least.

The derived freshwater species **HC_5** calculated from long-term NOEC values was **1.312 mg/L** (Fig 2B) for all data and **0.464 mg/L** (Fig 2C) for only acute exposures, both flagged red. For both models the most sensitive test species was the algae *Chlorella sp.* while the least sensitive was the gammaproteobacteria *Vibro fisheri*.

CONCLUSIONS

There is a major lack of experimental data of SiO_2 NM ecotoxicity for terrestrial species. To our knowledge, this is the first SSD model developed for SiO_2 NM on terrestrial species.

Aquatic species are one order of magnitude more sensitive to acute exposure to SiO_2 NM than terrestrial species. Alga species are more sensitive under both exposure scenarios.

The SSD model allowed for hazard classification of SiO_2 NM, suggesting that, reduction of hazard in freshwater alga species should be accounted for in the context of SbD of nanoforms containing SiO_2 NM.

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