Prospective environmental risk assessment of nanocellulose for Europe

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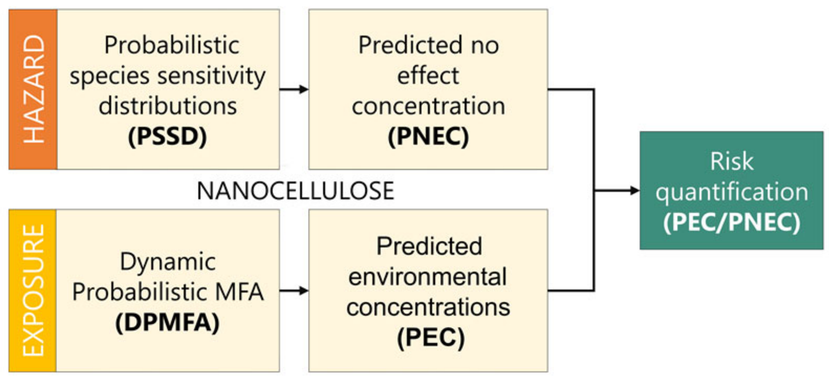
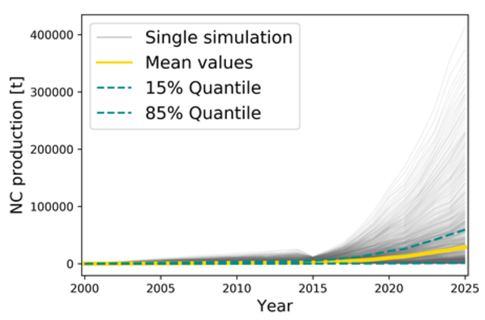
Introduction

- The appealing physicochemical properties of nanocellulose (NC) have led to increasing interest from research and industry.
- This growing interest and use will unavoidably lead to increasing release into the environment.
- Although largely regarded as non-toxic, knowledge gaps surrounding the impacts of NC on the environment still exist and data remains scares.
- This study aimed to quantitatively assess the environmental risk of NC by characterizing both environmental exposure and hazard within the surface water compartment of Europe.

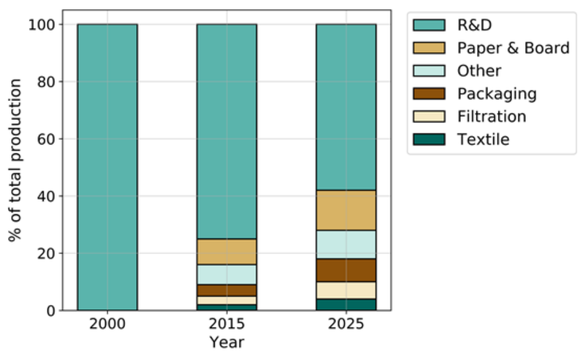
Methods



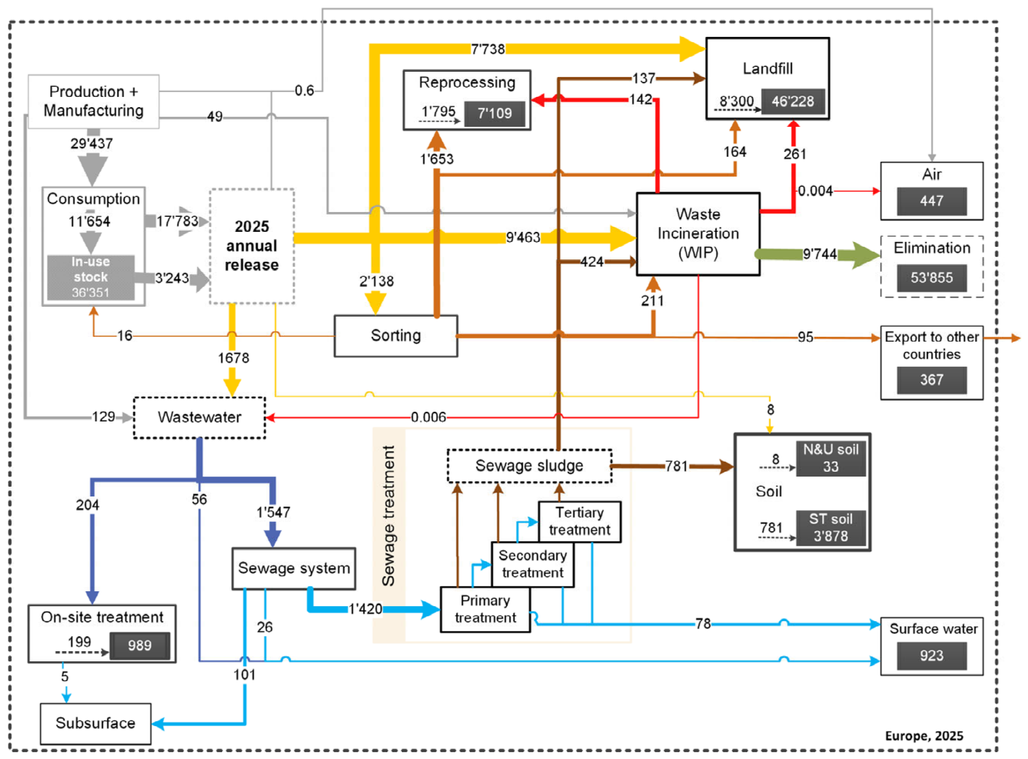
Results: Exposure Assessment



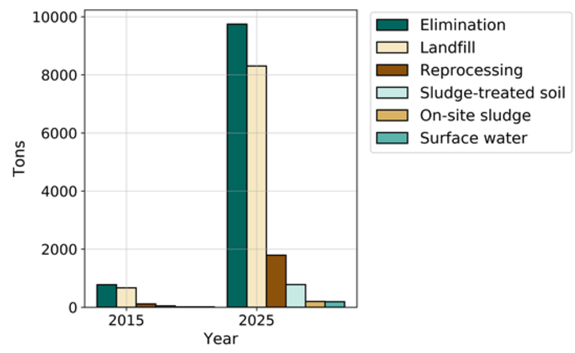
Evolution of nanocellulose production between 2000 and 2025 in Europe.



Allocation of nanocellulose to product categories between 2000 and 2025.



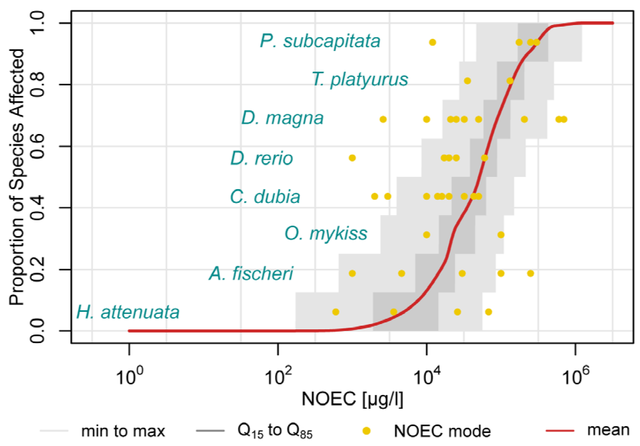
Material flows in 2025, in tons. Values are means of the probabilistic distributions. Black boxes represent sinks, i.e. amounts of nanocellulose having accumulated over time. 'ST soil': sludge-treated soil; 'N&U soil': natural and urban soil.



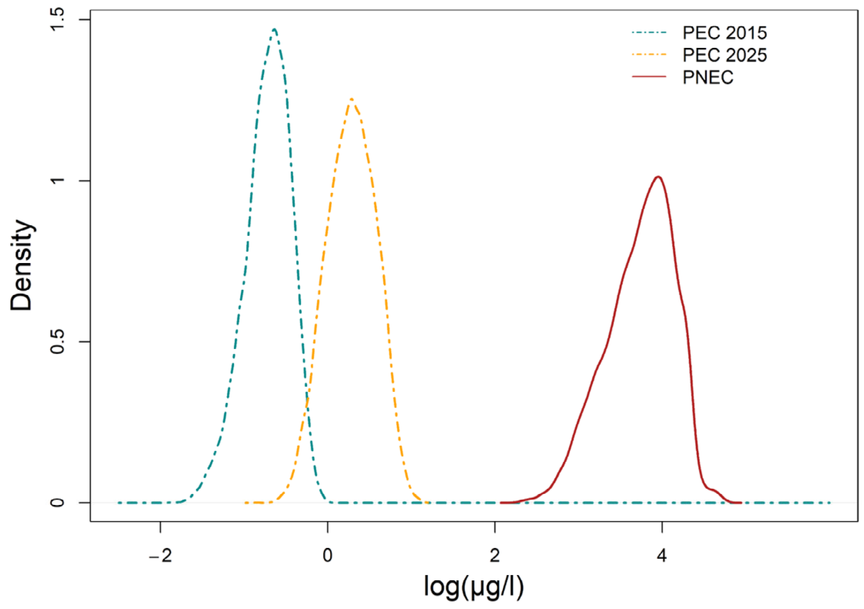
Inflow of nanocellulose to various stocks and sinks in 2015 and 2025.

- A wide variety of applications for NC were identified. The 'R&D' category represents the largest share of produced NC.
- A third of the inflow to 'Production', 'Manufacturing', and 'Consumption' (PMC) enters the 'In-use stock', released during later time-periods.
- All compartments see an increase in inflows over time, with those to the 'Elimination', and 'Landfill' compartments increasing most markedly by 2025.
- Current and future production volumes remain uncertain. The high volumes used as input data represents a 'worst case scenario'.

Results: Hazard Assessment and Risk Characterization



PSSD in freshwater, based on No Observed Effect Concentration (NOEC) values.



Comparison of the 2015 and 2025 PEC and PNEC distributions. An overlap of PEC and PNEC curves would signify that a risk exists.

- The mean value of the PNEC, calculated by taking the 5th percentile of the PSSD, was 7.7 mg/l.
- The PEC distributions for 2015 and 2025 were computed based on the mass of NC in the surface water compartment, resulting from the DPMFA.
- Even considering increased accumulation of NC, the Risk Characterization Ratio value for 2025 remains well below one, indicating low risk.

Risk Characterization Ratio (RCR) of nanocellulose in the surface water compartment.

RCR	2015	2025
Mean	6.9×10^{-5}	7.1×10^{-4}
Mode	2.0×10^{-5}	2.6×10^{-4}
Q15	1.1×10^{-5}	1.0×10^{-4}
Q85	1.2×10^{-4}	1.2×10^{-3}

Outlook and Conclusion

- In-depth risk analyses of novel materials are crucial to ensuring the safe development and commercialization of nano-containing products.
- This study represents a first prospective environmental risk assessment of nanocellulose within the surface water compartment at a regional scale with concentrations averaged across the territory.
- Results from this quantitative analysis give an optimistic outlook for the future of nanocellulose.

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