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## Supplementary material

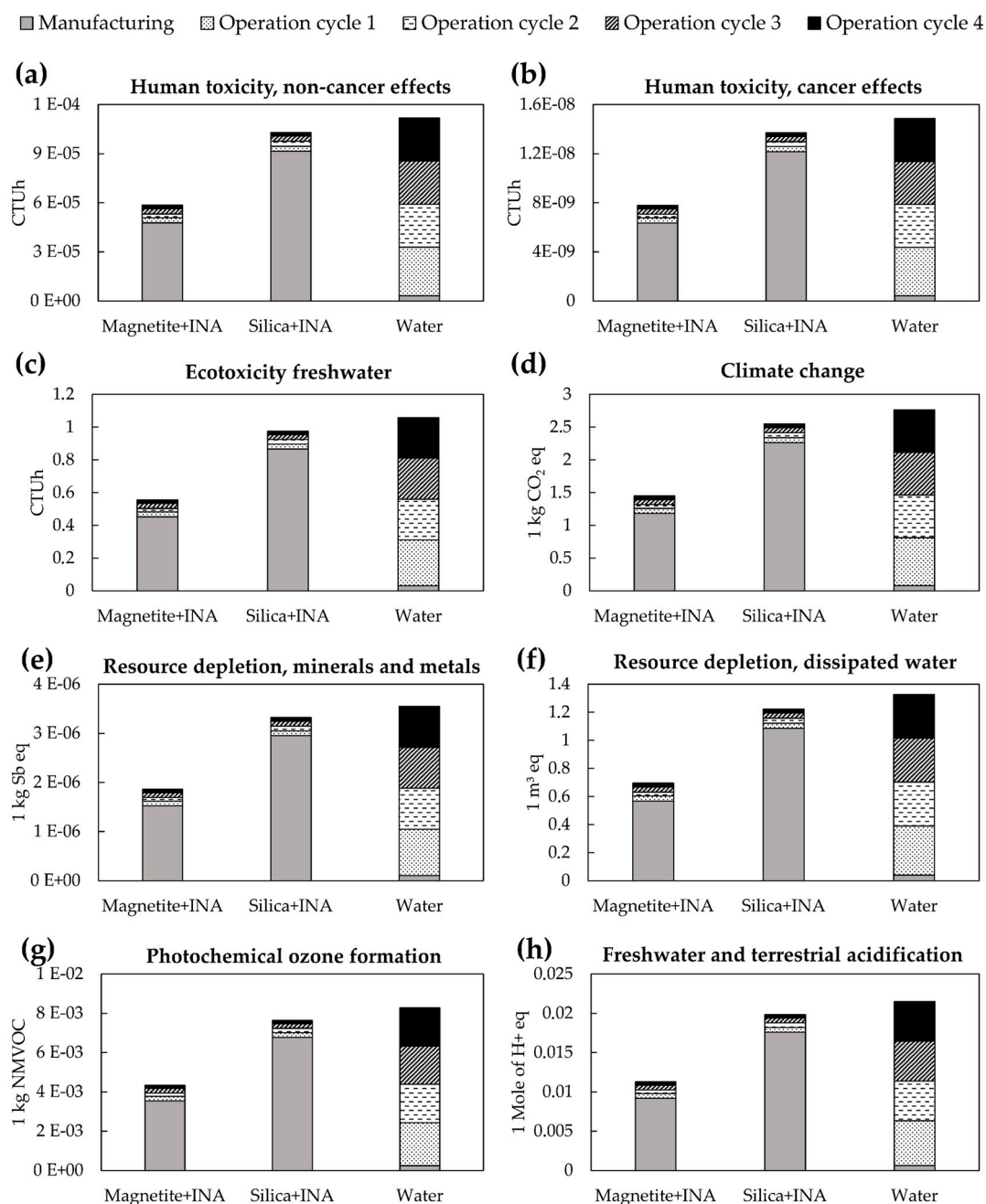
# Life Cycle Assessment of Functionalized Bionanocompounds with Ice Nucleation Protein for Freezing Applications

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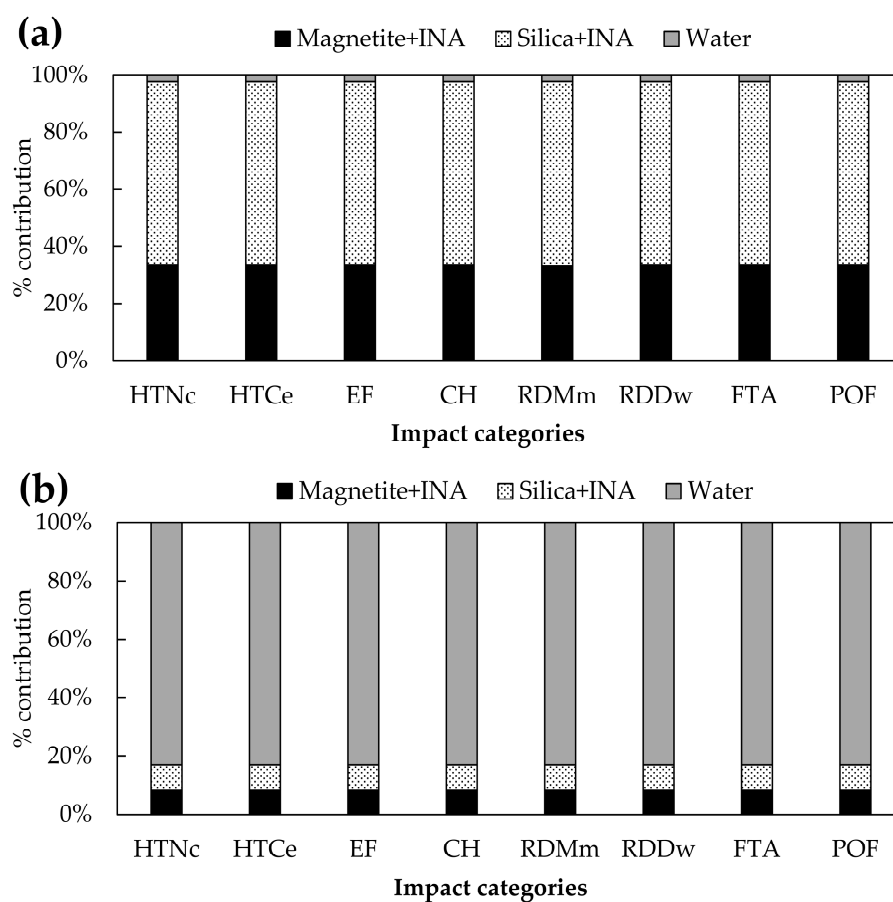
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**Figure S1.** Impact assessment results of the manufacturing and operation stages: (a) Human toxicity, non-cancer effects, (b) Human toxicity, cancer effects, (c) Ecotoxicity freshwater, (d) Climate change, (e) Resource depletion, minerals and metals, (f) Resource depletion, dissipated water, (g) Photochemical ozone formation, (h) Freshwater and terrestrial acidification.



**Figure S2.** Contribution analysis of Magnetite+INA bionanocompound, Silica+INA bionanocompound, and water: (a) Manufacturing stage and (b) Operation stage.