Natural Deep Eutectic Solvents: A Multifunctional Solvent for Sustainable Microplastics Detoxification

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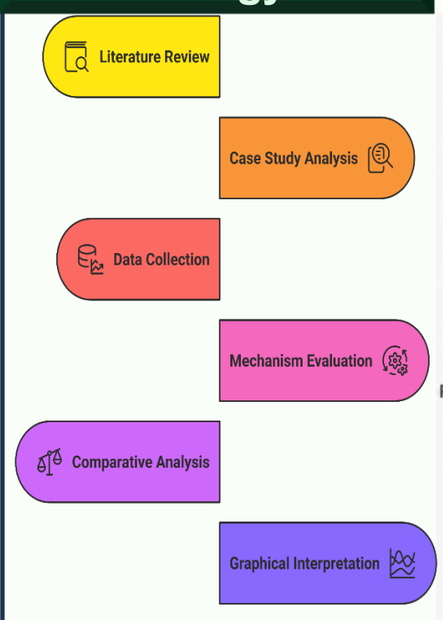
Abstract

Natural Deep Eutectic Solvents (NADES) are green solvents formed by combining a **hydrogen bond acceptor (HBA)** and a **hydrogen bond donor (HBD)** to create a stable hydrogen-bonded liquid system. NADES can be classified into **sugar-based, organic acid-based, amino acid-based, and choline chloride-based systems**, many of which are produced from **agricultural residues and biomass**. Common examples include **choline chloride** combined with **urea, glycerol, citric acid, or glucose**. In this study, NADES are explored for **microplastic detoxification in soil**. Their hydrogen-bond network interacts with polymer chains, weakening internal forces and promoting fragmentation of microplastics. Due to their strong solvency, biodegradability, and low toxicity, NADES offer a sustainable and environmentally safe approach for soil remediation.

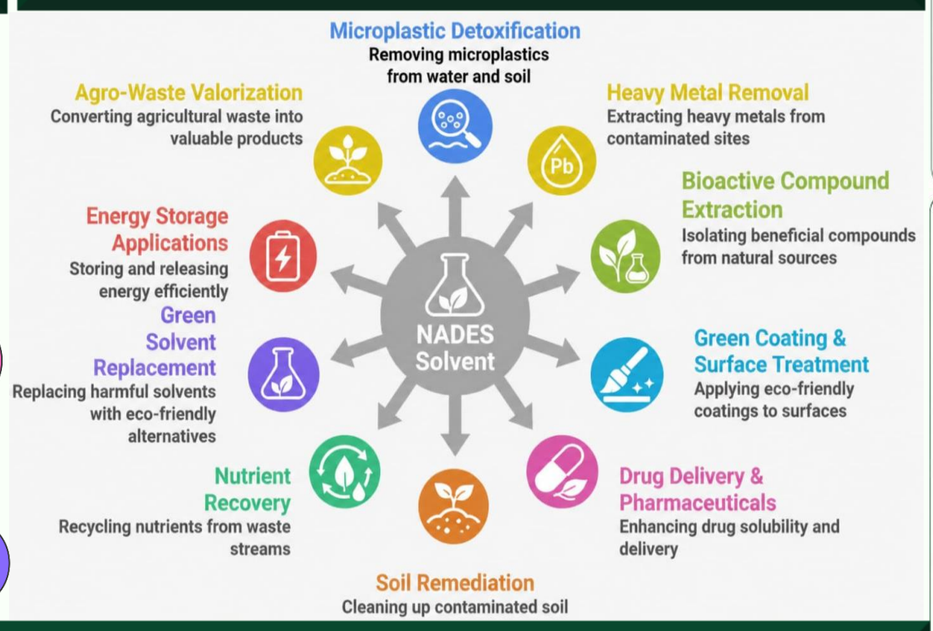
Problem Statement

Global plastic production exceeds **400 million tons/year**, generating persistent **microplastics (<5 mm)** that accumulate in soil and water systems. Agricultural practices such as **plastic mulching, wastewater irrigation, and biosolids** introduce large amounts of microplastics into soils, disrupting **soil structure, water retention, microbial activity, seed germination, root growth, and nutrient uptake**. Alarmingly, humans may ingest nearly **5 grams/week**, with microplastics detected in **blood, lungs, placenta, and brain tissues**, raising serious concerns about **inflammation and hormonal disruption**.

Methodology



Multifunctional Uses of NADES



Microplastic Detoxification Mechanism

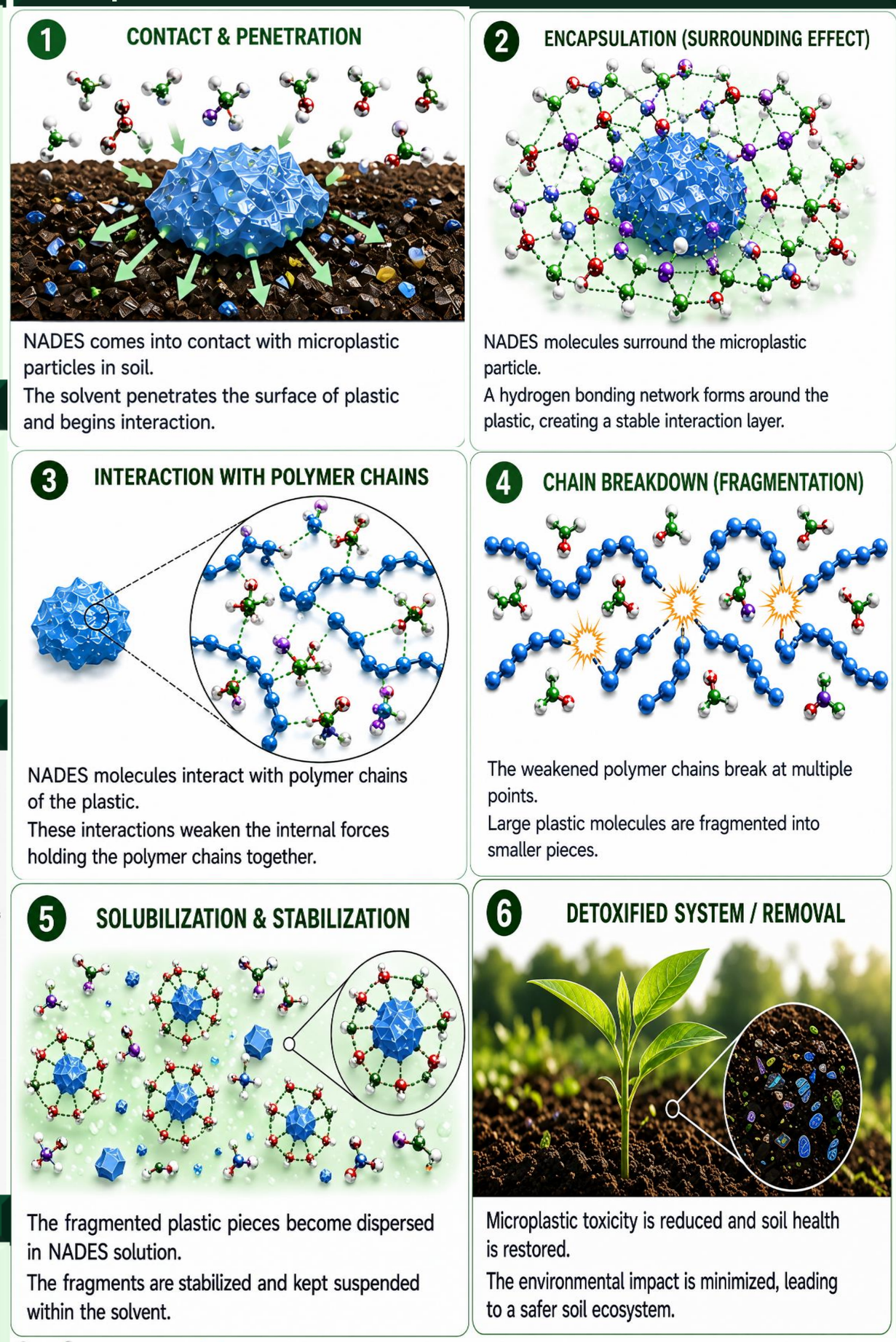
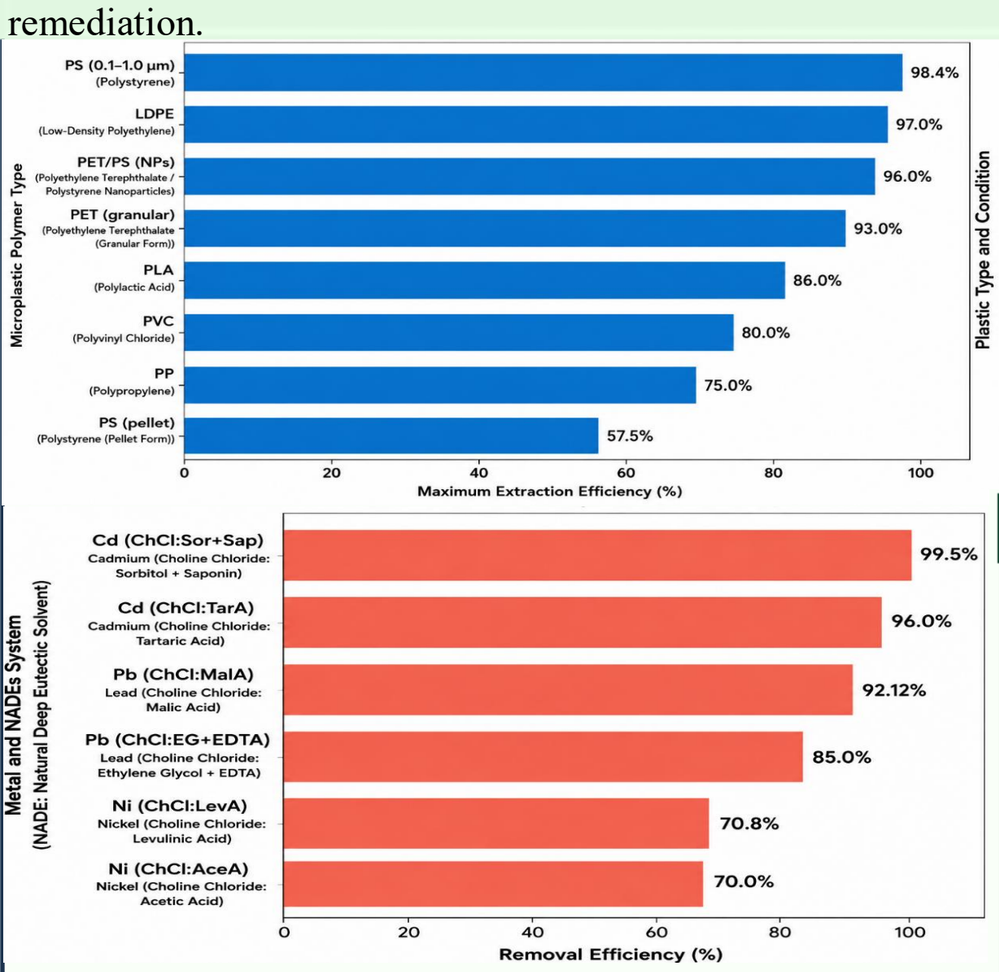


Figure 1: Conceptual mechanism of microplastic detoxification in soil using Natural Deep Eutectic Solvents (NADES)

Results and Graphs

NADES showed excellent remediation potential in **soil and water systems**. Hydrophobic NADES achieved **>95% microplastic removal**, including up to **98.4% nanoplastic extraction**, while **choline chloride-based NADES** removed up to **99% heavy metals** under optimized conditions. In aquatic systems, NADES achieved **95–99% extraction** of **micro- and nanoplastics** in a **single-step process**, highlighting their role as **green, high-efficiency solvents** for environmental remediation.



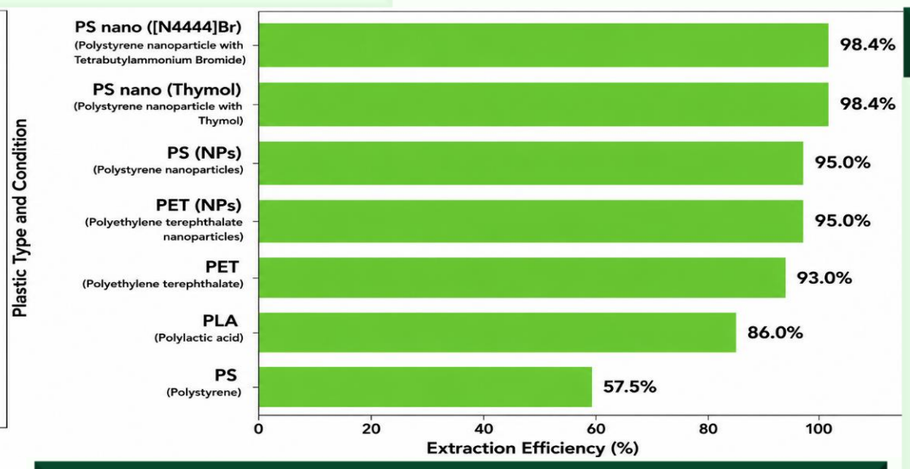


Figure 2: Comparative Removal Efficiency of Microplastics and Heavy Metals from Soil and Aquatic Systems Using NADEs

Conclusion

NADES are **multifunctional green solvents** with strong potential for sustainable **microplastic detoxification** in soil and water systems. They can weaken and fragment **polymer structures**, reducing microplastic persistence and toxicity. Besides microplastic remediation, NADES are also effective in **heavy metal removal** and **bioactive compound extraction**. Their **biodegradable**, **low-toxicity**, and **renewable** nature makes them a promising alternative to conventional chemical solvents for future **environmental remediation**.

References

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