Environmental and Water Resources Engineering, and Center for Water and the Environment Seminar Series Presents:

TEXAS

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Beyond the Bulk: Mechanistic Insights into Nanoplastic Release and the Environmental Fate of Polymers

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The linear economy of synthetic polymers systematically results in the vast majority of the materials being relegated to landfill accumulation and environmental leakages. With global plastic production projected to triple by mid-century, understanding their environmental fate is paramount. While bulk plastics are visibly persistent, their environmental degradation generates a complex spectrum of highly mobile products, including micro- and nanoplastics (MP/NPs), dissolved carbon, and CO2. Among these, NPs are of particular concern because they readily infiltrate biological tissues yet remain notoriously difficult to quantify and characterize. Furthermore, because accurate lifetime estimations rely on tracking the mass of full spectrum products, the current scarcity of data across all degradation pathways severely limits these calculations. Such foundational estimations are essential for conducting robust risk and life cycle assessments, ultimately informing science-based policymaking.

In this talk, I will highlight our recent efforts to bridge these knowledge gaps by harmonizing plastic degradation data and advancing the mechanistic understanding of NP release. First, utilizing our comprehensive degradation database harmonized from 290 peer-review articles, I will present our population balance modeling of polystyrene to predict its product mass distribution and MP/NP persistence across extended timescales. Second, I will explore mechanical degradation—a dominant yet understudied mechanism for NP release in terrestrial and coastal environments. Using novel lateral force microscopy-based nanoscratch methods coupled with macroscopic abrasion experiments, I will discuss new release behavior of low-density polyethylene at the single-asperity and sand grain level, more complex than previous understanding. We reveal how factors such as photo-oxidation, normal force, and additive formulation could govern NP release. Finally, our quantitative nanomechanical mapping demonstrates that NPs possess distinct material properties from bulk plastics, challenging the current toxicity studies largely relying on ideal model nanoplastics. Ultimately, this work advances our understanding and prediction for MP/NP exposure and effects, enabling the early design, selection, and management of polymer materials for responsible environmental outcomes

Bio:

Dr. Boya Xiong is an assistant professor in the Department of Civil, Environmental, and Geo-Engineering at the University of Minnesota, Twin Cities. Dr. Xiong's research focuses on the interface of polymer science and environmental engineering, to i) elucidate the fundamental mechanisms of polymer degradation that shape the fate, impact, and design of polymers; ii) develop novel biobased material for membrane processes to mitigate pathogens and fouling in water and wastewater treatment. Her work has been funded by NSF, ACS, CDC, and the state of Minnesota ($5.16 M in total with 60% her share). She was a recent NSF CAREER awardee and a McKnight Land-Grant Professor at UMN. She was selected as ASCE MN chapter Young Engineer of the Year in 2023 and an American Academy of Environmental Engineers and Scientists 40 Under 40 awardee in 2024. Xiong earned a Ph.D. in Environmental engineering at Pennsylvania State University where she also obtained her M.S. in Agricultural and Biological Engineering. Xiong earned a B.S. in Biotechnology from East China University of Science and Technology. Prior to her appointment, Xiong was working as a postdoctoral associate at MIT.

EWRE Seminar Committee Members: Ana Lăcău, Ella Junker, Hani Ghamkhar, Julia Barkelew, Tzu-An Lee
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