C209

Floating Debris: Challenges for Flood Risk Management

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Flood events often transport significant quantities of floating debris, including cars, containers, wood, and other materials, leading to enhanced hazard on humans and environment, e.g. the dramatic example of the October 2024 Valencia floods in Spain (Franca et al. 2024). During floods, urban debris becomes mobile, transforming into Urban Flood Drifters (UFDs), which threaten lives, damage property, clog drainage systems, and consequently exacerbate flood risks (Bayón et al. 2024). Plastic litter, in particular, poses a severe threat to aquatic ecosystems and imposes substantial economic burdens on local authorities due to the high costs of cleanup and removal. Despite the clear risks posed by floating debris, the European Floods Directive primarily focuses on hydrological parameters, such as water levels and flow velocities, largely overlooking the role of transported sediments and debris in flood risk assessments (Ludwig et al. 2023). This gap in flood management policy underscores the need for a comprehensive understanding of the dynamics of floating debris during flood events, which is critical for enhancing urban resilience and ecological protection.

We present results of research on the hydraulic transport of floating debris, focusing on the inception of motion and transport mechanics of large debris, plastic and urban litter during floods. Our findings aim to contribute to effective management strategies to mitigate the environmental and infrastructural impacts of floating debris during urban flooding events.

Our research investigates the mechanics of floating debris transport during floods using a combination of experimental, numerical, and theoretical approaches (Valero et al. 2024). We analyze the inception of motion, transport mechanisms, and spatial distribution of large-scale debris and urban litter. Key findings highlight the factors influencing debris mobilization, including water depth, flow velocity, and object characteristics. We developed a mechanistic stability model for UFDs that predicts their motion based on probabilistic analyses of flotation, sliding, and toppling behaviors.

Figure 1 – Clogging of infrastructures in river Pfinz, Karlsruhe

Furthermore, our research on the mechanics of plastic transport, shows the intricate interplay of material properties, shapes, and scales, which challenges existing models of transport typically used for sediment. Natural sediments typically have limited geometry, fairly uniform shapes, and basically are composed of a single material. Their transport is governed by the equilibrium of gravitational, buoyancy, turbulent, and shear forces. In contrast, plastic particles are more complex, exhibiting multiple scales, intricate shapes, and a heterogeneous composition of various materials. While their transport is also influenced by gravitational, buoyancy, turbulent, and shear forces, additional factors are present for plastic transport, such as surface tension, varying restitution rates, buoyancy, chemical forces, and the effects of aging and weathering. These differences in physical and chemical properties result in distinct behaviors during transport, with plastics often showing more variable and less predictable patterns than natural sediments.

The findings herein are essential for developing mitigation strategies, such as debris retention and capture systems, and incorporating floating debris considerations into urban flood planning. We defend thus that it is time to integrate debris transport dynamics into urban flood risk assessments. Our probabilistic stability curves for various debris categories can inform infrastructure design, ensuring that cities are more resilient to floods. Additionally, the insights gained from our research contribute can be used to targeted policies for reducing the environmental and infrastructural impacts of floating debris.

Our research aims at bridging a knowledge gap in flood risk management and hints for future research on the environmental and mechanical implications of floating debris. Ultimately, they will contribute to sustainable urban planning and effective flood mitigation strategies that account for both hydrological and debris-related risks.

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