The future and fate of microplastics in fluvial systems; Potential impacts on biogeomorphology of urban rivers.

"Plastics…there's a great future in plastics"—*The Graduate, 1967*

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Abstract

In 1967 there was, indeed, a great future in plastics, as Mr. McGuire foretold an ambivalent Benjamin Braddock. Half a century later, plastic pollution is a major environmental concern at all scales of observation. The presence and impact of microplastics, plastic particles <5 mm in diameter, in the marine realm has gained attention as a serious threat to ocean ecosystems. Very little is known, however, about microplastic release on land, storage in soils and sediments and transport by run-off and rivers. This represents a major oversight, as river systems are the source of a great amount of microplastic and are a transit route for microplastics headed to the ocean. The proposed research will assess the presence of microplastics in the river bed and bank sediment from select urban rivers in Texas. Sediment samples will be analyzed using a Raman confocal microscope for microplastic presence. Samples will be collected from urbanized portions of at least two rivers and downstream for approximately five miles, thus allowing for assessment of transport and settling rate of microplastics in the fluvial environment.

Justification

This research will contribute to TWRI's priority of addressing major water quality impairments in Texas, which includes bacteria, dissolved oxygen, mercury, and other hazardous contaminants. The effect of microplastics on human health is yet unknown, as it is a potential threat only recently realized. As research progresses into the effects of microplastics on ecology and human health, understanding of their distribution is also necessary. This project will contribute to that knowledge gap.

Microplastics are defined as plastic remnants under 5mm in diameter and are washed into the marine environment with other sediments. Their effects in drinking water are still being researched (Storck et al. 2015; Pivokonsky et al., 2018). Studies of ingestion of microplastics by mammals, including humans, have shown that they can be transported into blood and lymph and from placenta to fetus (Hussain et al., 2001; Wick et al., 2010; Storck et al., 2015). In some animals, microplastics were linked to capillary inflammation and to reproductive changes (Brown et al. 2001; Froehlich et al. 2009; Storck et al. 2015).

Much research has been done regarding microplastics in the marine realm, but less has been performed in rivers. This is concerning for drinking water quality as two-thirds of Americans' drinking water comes from rivers and streams (American Rivers, 2017). It also creates a knowledge gap of the potential impact on the fluvial ecosystem and biogeomorphology. Urbanization seems to play an important role; McCormick et al. (2014) tested for microplastics in an urban river upstream and downstream of Chicago and found that microplastic concentration increased from 1.94 per m^3 upstream of Chicago to 17.93 per m^3 downstream.

Microplastics have the potential for being a catalyst for ecological collapse, if their release into the aquatic environment is not checked. Microparticles are consumed by primary suspension feeders or sediment deposit feeders, leading to excessive plastic buildup in the digestive tract of secondary and tertiary consumers (Di-Meglio and Campana, 2017; Matsuguma et al. 2017; Rezania et al., 2018). This poses a clear concern for ecological health and for human health of those consuming water contaminated with microplastic. Ecological health also affects geomorphic processes, as organisms affect sediment entrainment and transport by either stabilizing or destabilizing sediment. For example, burrowing organisms disrupt sediment and allow for entrainment at lower velocities, whereas biofilms protect sediment from erosion by covering them with a smooth surface, decreasing the likelihood of entrainment (Polvi and Sarneel, 2018). Macrophytes are associated with increased bed stability, in some cases doubling the force needed to dislodge sediment (Fritz and Feminella, 2003; McBride et al., 2007; Polvi and Sarneel, 2018). In contrast, some fluvial organisms, such as crayfish (common in Texas rivers), are destabilizers (Albertson and Allen, 2015). In the United Kingdom, a crayfish infestation induced sediment entrainment through bioturbation. In crayfish-impacted areas, the critical shear stress required to move sediment can decrease by 75%, resulting in a greater transport of fine sediment (Statzner, 2008; Statzner, 2012; Polvi and Sarneel, 2018).

The role of biotic versus abiotic factors in stream morphology varies among fluvial systems; rivers with lower discharges and smaller grain sizes seem to be more heavily impacted by biotic factors, whereas those with higher discharges and larger grain sizes are dominated by physical forces, not biological (Albertson and Allen, 2015; Polvi and Sarneel, 2018). As rivers in the proposed study area are low-gradient, low velocity, and contain predominantly mud and sand-sized sediment, it is reasonable to expect organisms to play an important role in their geomorphic adjustment.

The proposed research will build upon the applicant's doctoral dissertation which addresses the effects of urbanization on the morphological stability of river channels. Having already traversed these rivers upstream and downstream of urban centers, put-in and take-out locations as well as in-stream hazards are already identified and expected. This proposed research will entail travelling these rivers again in an aluminum canoe with wooden paddles (to reduce potential for plastic contamination), collecting bed and bank sediment into glass containers using wooden and metal post-hole diggers or gardening shovel, and transporting sediment to the Texas A&M Materials Characterization Facility for testing for microplastic content.

Objectives and Timeline

The objectives of this study are as follows:

i) Determine whether there is a microplastic presence in bed and bank sediment and water of selected urban rivers.

ii) Determine levels of microplastics in selected rivers.

iii) Assess the effects of urbanization on microplastic levels in sediment.

iv) Assess the transport and settling rate of microplastics in low-gradient rivers such as those in the study area.

The timeline of this study is as follows:

Spring 2019: Continue literature review of microplastic contamination of rivers. Research entrainment velocities of sediment with mass and size similar to common microplastics.

Summer 2019- Fall 2020: Collect sediment from selected rivers

Fall 2019- Fall 2020: Analyze sediment in Raman confocal microscope for microplastic presence.

Winter 2020: Report findings.

Expected Outcomes

It is expected that microplastics will be present in the sediment of at least one river. The Trinity River near Dallas has appalling levels of macroplastic pollution beginning immediately downstream of Dallas, and I hypothesize that this will be represented even in the sediment. The Brazos and Colorado Rivers have much lower levels of macroplastic pollution downstream of their respective urban centers, and I hypothesize the levels of microplastics in the river sediment will reflect this. If this hypothesis is supported, then this would allow for assessment of the effectiveness of proper macroplastic disposal in preventing microplastic contamination. If this hypothesis is not supported, and all rivers contain comparable levels of microplastic, then recognition of the gravity of microplastic as a formidable nonpoint source pollution is presented and further effort to contain its distribution will be necessary.

Intended Career Path

My goal is to continue in academia as a professor and researcher. I am interested in anthropogenically-sourced sediments and their effect on geomorphology. Anthropogenic sediments may influence geomorphology by affecting the ecological health of a system and thus influencing biogeomorphologic processes, and potentially by their differences in density, shape, and cohesiveness. As further research, after establishing the levels of microplastics in the fluvial environment, I am interested to determine their impact on channel armoring and stability.

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