Spring 2015

The Effect of Microplastic Fibers on the Freshwater Amphipod, Hyalella Azteca

K J. Talley
Clemson University

S Y. Au
Clemson University

S J. Klaine
Clemson University

The Effect of Microplastic Fibers on the Freshwater Amphipod, *Hyalella azteca*

K.J. Talley[3], S.Y. Au[1,2] and S.J. Klaine[2,3]

[1]Graduate Program in Environmental Toxicology, [2]Institute of Environmental Toxicology, Clemson University, Pendleton, SC, [3]Department of Biological Sciences, Clemson, SC

Abstract

Microplastics (MPs) are a growing and persistent contaminant in aquatic ecosystems. There is a wide variety of shapes that MPs can take, with fibers being the most prominently found in marine systems. Few studies have investigated the toxicological implications of MP exposure to freshwater organisms, and none so far has quantified the effect that fibers, as compared to spherical particles, may have on aquatic organisms. A 42-day chronic exposure to polypropylene MP fibers (0 – 22.5 MPs/mL) was conducted in order to investigate potential effects on mortality, growth, reproduction, and egestion times. Significant mortality was only observed at the highest concentration (22.5 MPs/mL). Growth and reproduction is also significantly less than the control at all exposures to MP fibers, with no mating pairs forming at all in concentrations greater than 5.63 MPs/mL. Interestingly, gut clearance times after exposure to MP fibers is also greater at concentrations greater than 5.63 MPs/mL. Delays in reproduction and growth may result from deficiencies in nutrient uptake. This study provides further insight on how the shape of MPs may hold significant implications on their toxicity to aquatic organisms.

Background

Microplastic (MP) Production:
- Annual global plastic production is approximately 300 million tons, and is continuing to increase (Claessens et al, 2011).
  - Polypropylene:54 million tons (Plastics—the Facts).
  - It is unlikely plastic production will decrease due to it's increasing demand and use.

Biological effects of MPs:
- Decrease in food intake (Cole et al., 2013).
- Translocation from the gut (Browne et al., 2004).
- Aggregation in the gut (Browne et al., 2004).

Presence in Aquatic Systems:
- 80% of plastics arrives to marine systems by land sources (Frias et al, 2014)
- Freshwater systems are likely contributors of this plastic load. (Claessens et al., 2011)
- Aquatic systems act as a sink for most plastics.

Potential Pathways for MP Transport and Biological Interactions

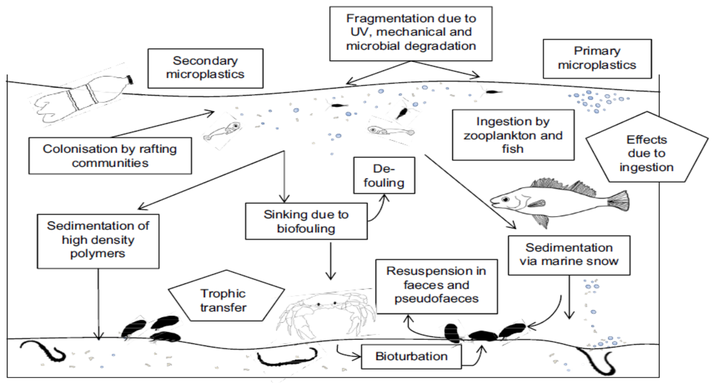
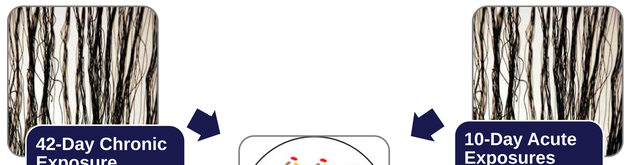


Figure 1: Potential pathways for the transport of microplastics and its biological interactions. Source: Wright et al. 2013

Methods



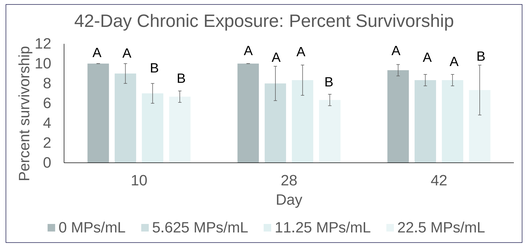
Objectives

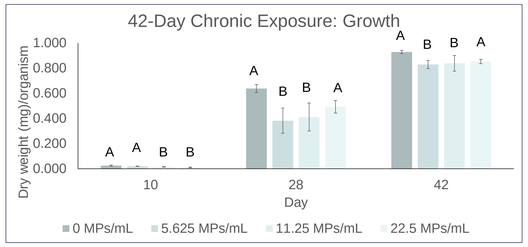
1. **Evaluate the acute toxicity of polypropylene microplastic fibers to *Hyalella azteca.***
2. **Evaluate the chronic toxicity of polypropylene microplastic fibers to *Hyalella azteca.***

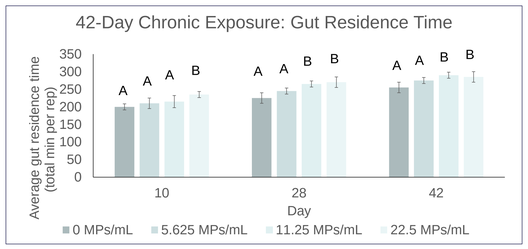
Hypothesis

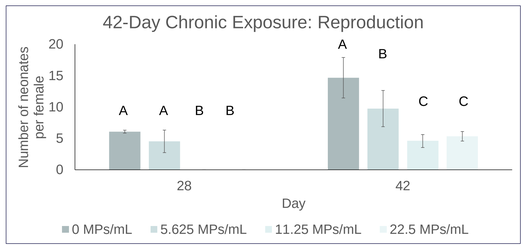
- **MPs will have adverse effects on the amphipods, specifically in regards to reduced growth and reproduction.**
- **MPs will have adverse effects on the amphipods by way of increased mortality and egestion times**

Results









Different letters indicate significant differences ($p < 0.05$) between concentrations at specific time points.

Discussion

Decreased Food Uptake:
- Previous studies show that when zooplankton ingest microplastics, their consumption of algae decreased as a response to MP exposures (Cole et al., 2013).
- This lack of dietary food could lead to a wide variety of indirect effects (reduced growth to ultimately death).

MP Ingestion Aggregation in the Gut:
- Reduced growth may result from the blockage of uptake channels/veins in the gut track, potentially impacting:
  - Growth, reproduction, and survival behavior (Derraik, 2002)

Impacts of Growth on Reproduction:
- Smaller females have smaller brood sizes (number of neonates) (Strong et al, 1972).

MP Egestion:
- As MP exposures to zooplankton increases, MP egestion time also increases.

Conclusions

Survivorship:
- There were significant decreases in survivorship at concentrations greater than 11.25 MPs/mL.

Growth:
- Day 10: There was significant decreases in growth at concentrations greater than 11.25 MPs/mL.
- Day 28 and 42: There was significant decreases in growth at concentrations 5.625 and 11.25 MPs/mL.

Gut Residency Time:
- There was significant increases in gut residence time at concentrations greater than 11.25 MPs/mL.

Reproduction:
- There was significant decreases in reproduction at concentrations greater than 11.25 MPs/mL.

Acknowledgements

- Klaine Lab
- Sarah Au
- Amphipods

References

1. Cole, Matthew, Pennie Lindeque, Elaine Fileman, Claudia Halsband, Rhys Goodhead, Julian Moger, and Tamara S. Galloway. "Microplastic Ingestion by Zooplankton." *Environmental Science & Technology* 47.12 (2013): 130606145528005. Web. 11 Mar. 2015.
2. Browne, Mark A., Awantha Dissanayake, Tamara S. Galloway, David M. Lowe, and Richard C. Thompson. "Ingested Microscopic Plastic Translocates To The Circulatory System Of The Mussel,(L.)." *Environmental Science & Technology* 42.13 (2008): 5026-031. Print.
3. Claessens, Michiel, Steven De Meester, Lieve Van Landuyt, Karen De Clerck, and Colin R. Janssen. "Occurrence And Distribution Of Microplastics In Marine Sediments Along The Belgian Coast." *Marine Pollution Bulletin* 62.10 (2011): 2199-204. Web. 11 Mar. 2015. <www.elsevier.com/locate/marpolbul>.
4. "Plastics--the Facts 2014/2015." *PlasticsEurope*. PlasticsEurope, Jan. 2015. Web. 11 Mar. 2015. <http://www.plasticseurope.org/plasticssustainability.aspx>.
5. Frias, J.p.g.l., V. Otero, and P. Sobral. "Evidence of Microplastics in Samples of Zooplankton from Portuguese Coastal Waters." Marine Environmental Research 95 (2014): 85-95. Print.
6. Derraik, J. G. B. The pollution of the marine environment by plastic debris: a review. Mar. Pollut. Bull. 2002, 44 (9), 842–852.
7. Strong, Donald R. "Life History Variation Among Populations of an Amphipod (Hyalella Azteca)." *Ecology* 53.6 (1972): 1103. *Www.jstor.org. Ecology*. Web. 11 Mar. 2015. <http://www.jstor.org/stable/1935422>.

Future Work

Future research endeavors could span looking into:
- the mechanism of action or hindrance on the uptake of nutrients caused by MP ingestion.
- fiber capacity as contaminant carriers.