The Effects of Microplastics On Microbial Diversity

Obed Meraz

California State University, Stanislaus

Introduction

Since the inception of plastics in the early twentieth century, it was recognized as a revolutionary material. Plastics have then developed significant applications in every major industry but have presented a problem. Our increasing reliance on plastics has allowed plastics to permeate nearly every environment across the world. Plastic interacts in various ways with every trophic level in an ecosystem from choking larger organisms to disrupting microbial communities. This potential to manipulate the environment warrants an understanding of the effects of plastic pollution on all life, especially the most sensitive forms of living microorganisms.

Research Question

How does the presence of microplactics affect microbial diversity?

The definition set by the U.S National Oceanic and Atmosphere Administration for microplastics is any piece of plastic less than 5 millimeters in length. The generation of microplastics is a continuous process as plastics degenerate from exposure to heat, oxygen, and UV radiation. As a result, anywhere plastics are found microplastics appear. However, due to the size of microplastics, they are much more mobile. Microplastics near-ubiquitous nature gives them the potential to interfere with the local ecologies they pervade. The negative effects of microplastics on the larger organisms are much more understood due to the feasibility of conducting a study and the visibility of the potential impact. However, the impact of microplastics on microorganisms is not inherently understandable. One would benefit from asking the question of how does microplastics affect microbial diversity?

Background and Literature Review

Microplastics in a free-floating environment develop into micro-habitats called “Plastispheres” (Zettle, et al., 2013). These plastispheres, as suggested by Zettler, Mincer, and Amaral-Zettler represent a new ecological niche that is drastically different from the surrounding environment (2013). The study suggests that certain groups of microorganisms utilize the microplastic surface as a substrate to inhabit. Eventually, the community of pioneering organisms will develop into a complex network of biotic elements called a biofilm (Woodcock, Sloan, 2017). As Woodcock and Sloan would suggest, a biofilm is developed through a hierarchy of interacting layers consisting of different types of microorganisms. Microplastics facilitate this process, disrupting the natural formation of biofilms on other substrates. Biofilms alter the chemical nature of microplastics, converting a previously inert substance into one capable of interacting with chemicals in the environment. The presence of microplastics in freshwater habitats represent an unnatural stressor that an induces adverse metabolic reactions. A study conducted by Xiao and colleagues examines how the presence of microplastics negatively affected Euglena gracilis (Xiao, et al., 2020). The interactions between polystyrene microplastics and E. gracilis resulted in inhibited growth and the down-regulation of genetic and metabolic processes. Microplastics appear to selectively favor certain groups of microorganisms by being a stressor of some and providing a

substrate for others. This selective trait changes the diversity of microbial communities that microplastics invade (Li, et al., 2020).

Acknowledgement

I would like to thank Dr. My Lo Thao for agreeing to be my mentor. She was provided guidance and support throughout the entirety of my project. I would also like to thank Dr. Suditi Gupta for teaching me all the skills necessary which allowed me to develop this project.

Methods

Design

This paper will take a qualitative research approach that will first describe a theoretical experimental design and cross-examine that with results from established experiments within the same field. Analysis will be based on inferences that can be made from results of established experiments and comparing it to key descriptions of expected microbial diversity.

Subjects

The focus of analysis will be oriented towards academics work whose results can extrapolated to compare to freshwater systems.

Materials

- Peer-reviewed academic journals

Expected Results

There exist a clear distinction between microbial communities which inhabit the plastic substrates as supposed to free floating microorganisms. The presence of a substrate alone is enough to drastically change the composition of a microbial community. This due to the difference between substrate capable microorganisms and free floating microorganisms. In a typical aquatic environment free floating microorganisms constitute the majority species until a substrate appears. Pioneering microorganism colonize the substrate which facilitates the growth biofilm over time. This appears to be true for all studies examine in this paper. Microplastics provide an abundant source of substrates which permeate all environments. California's freshwater system are vulnerable to the same processes. A key differences between the two systems is which species readily form substrates. In marine systems cyanobacteria often pioneer substrates while in freshwater environments it would be microalgae.

Significance

The majority of research in understanding the relationship between microplastics and microorganism have been focus on a marine setting. This has revealed significant insight on the role of microplastic as a pollution but the world would benefit from an understanding of how microplastic affect freshwater systems. Freshwater systems demonstrate a unique vulnerability to changes in microbial communities due to their intimate relationship with agriculture. A disruption in such a delicate balance could lead to lethal algal blooms or the destabilization of geochemical cycles. It would benefit those reliant on freshwater resources and concern with the environment to investigate whether microplastics have any effect on freshwater microbial diversity.

References

1. Woodcock, S., & Sloan, W. T.. (2017). Biofilm community succession: a neutral perspective. Microbiology. Microbiology. http://doi.org/10.1099/mic.0.000472

2. Li, C., Gan, Y., Dong, J., Fang, J., Chen, H., Quan, Q., & Liu, J.. (2020). Impact of microplastics on microbial community in sediments of the Huangjinxia Reservoir—water source of a water diversion project in western China. Chemosphere. Chemosphere.http://doi.org/10.1016/j.chemosphere.2020.126740

3. Xiao, Y., Jiang, X., Liao, Y., Zhao, W., Zhao, P., & Li, M.. (2020). Adverse physiological and molecular level effects of polystyrene microplastics on freshwater microalgae. Chemosphere. Chemosphere. http://doi.org/10.1016/j.chemosphere.2020.126914

4. Zettler, E. R., Mincer, T. J., & Amaral-Zettler, L. A.. (2013). Life in the “Plastisphere”: Microbial Communities on Plastic Marine Debris. Environmental Science & Technology. Environmental Science & Technology. http://doi.org/10.1021/es401288x

Contact

Obed Meraz

California State University, Stanislaus Honors Program

Email: omeraz@csustan.edu

Phone: (209) 648-2455