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WWU Research Intern - Investigating Particle Composition and Aquatic Chemistry Impacts on Microplastic Aggregation Behavior Through the Use of Nanopolymer-Nanoparticle Composites

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Project Title: Investigating Particle Composition and Aquatic Chemistry Impacts on Microplastic Aggregation Behavior Through the Use of Nanopolymer-Nanoparticle Composites

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Investigating Particle Composition and Aquatic Chemistry Impacts on Microplastic Aggregation Behavior Through the Use of Nanopolymer-Nanoparticle Composites

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Introduction

Understanding how microplastics act in environmental systems is of growing interest in the environmental toxicology field. Given the number of consumer and industrial grade plastic pollution, along with unknowns regarding their ability to sorb to other contaminants, it is key to understand how these microplastics behave in the environment. Microplastic pollution has the ability to not only negatively impact environmental health, but human health as well. Emerging results on microplastic trophic transfer alludes to the possibility that these plastics could trophic transfer (Athey et al., 2020). For example, when organisms are exposed to microplastics, along with the other contaminants sorb to the plastic, it can cause physical blockages and toxicity to the organism. If a human consumes that organism contaminated by microplastics, the evidence of organismal trophic transfer suggests a possible human exposure. An aspect that is important to understand in order to establish protective regulations is microplastic transport behavior. Various factors influence the transport of microplastics. Some examples include microplastic size, aquatic chemistry, biological influences, and mineralogy presence (Rauschendorfer, 2021).

In order to capture microplastic presence, this study used metal based microplastic tracers. However, there are some other common forms of tracers. The most common form are fluorescent tags. Different dyes are added into a sample and adsorbs to the polymer. With the use of fluorescent imaging, you can visually see the presence of microplastics. While this method is cost-effective and fast, this technique does not allow for environmentally relevant results. Only certain sizes can be used, eliminating the application of environmental weathering sizes (Karakolis et al., 2019). Another type is isotopic labeling. This method considers many environmentally relevant conditions such as tracing of carbon cycles and close size comparison between the tracer and environmentally exposed microplastics. However, little research has been done on the method and is highly expensive (Taipale et al., 2019). This study used metal based microplastic tracers, which contain a metal core encased within the polymer shell. These tracers are quantified using single particle inductively coupled plasma mass spectrometry (spICP-MS). The combination of these metal-based tracers and analytical instrumentation provides a tool that limits background interference and uses environmentally relevant concentrations (Keller et al., 2020).

Senior Project Goals

My goals for this project revolved around two aspects, gaining laboratory experience, and creating my own project from start to finish. Because of the COVID pandemic, I missed out on almost two years of lab experience. When I was entering my last year at Western, I was determined to gain as much lab experience as I can. Especially because I was planning on applying to graduate programs. Once starting the project, my goal shifted to seeing this research through to the end.

Methods

This experimental design focused on changes in attachment rate of microplastic tracers, regarding mineralogy and salinity. Sediment is often a mixture of clays, silts, metal oxide minerals, and other inorganic and carbon containing chemicals. Specifically, iron oxide (Fe2O3), sand (SiO2), and clay (aluminosilicates, i.e., kaolinite Al2Si2O4) were used to test mineral effects on attachment behavior. Sediment components were mixed into a salinity medium. The main salinity medium used represented a marine system (30 PSU). A Milli-Q medium was used as a control (0 PSU).

The test design was composed of three replicates and two treatment groups per run. 250-ml Erlenmeyer flasks contained approximately 100 mg/L of microplastic tracers, 200ml of either Milli-Q or 30 PSU (created by using instant ocean), 250 mg of sediment material, and a stir bar. The solutions were constantly stirred with the usage of stir bars and plates, for a total of one hour. The flasks were then transferred off the plate and allowed to settle for an hour. After settling, samples were taken every hour to obtain three-time frames (T0, T1, and T2). The samples were then be analyzed through ICP-MS.

Results

The data from this experiment showed that microplastics have a higher affinity to aggregate with clay than the other minerals in both Milli-Q and 30 PSU mediums (Figure 1 and

2). When comparing the raw data of the controls in respect to salinity, the control for Milli-Q presented uniform counts at similar peaks (Figure 3). However, the 30 PSU control had un-uniform counts at different heights. The differences in the raw control data does provide some background on the results from the 30 PSU experiment.

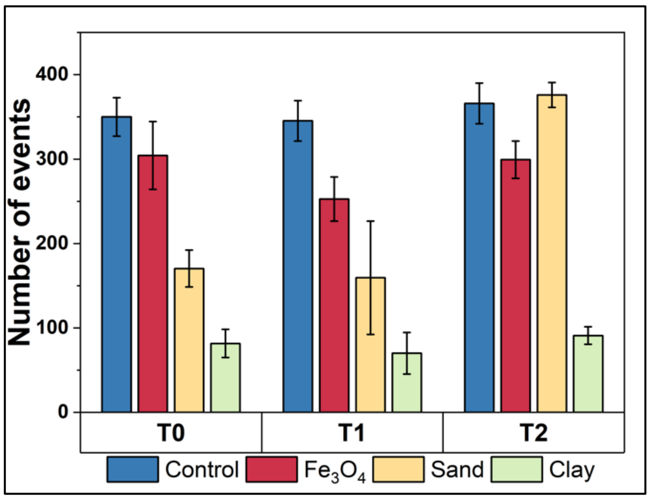

Figure 1: The difference in microplastic aggregation between Fe_3O_4, sand, and clay in a Milli-Q medium

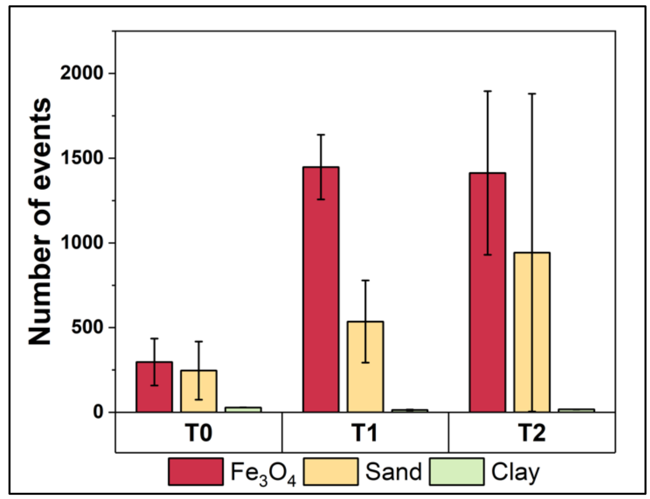

Figure 2: The difference in microplastic aggregation between Fe_3O_4, sand, and clay in a 30 PSU medium.

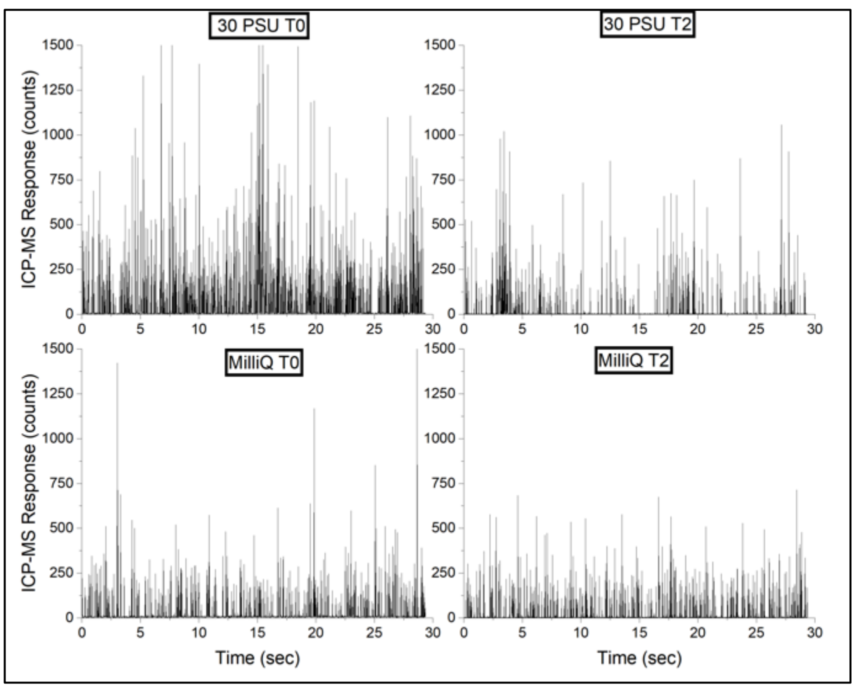

Figure 3: Raw particle intensities for tracers without any minerals present

Discussion

According to the data found in this study, there is evidence that microplastics have a higher affinity to bind with clay than the other minerals. In the 30 PSU medium, microplastics did exhibit potential aggregation behavior with more variable and intense events. The difference between counts in the 30 PSU control is likely from either potential carry over or fracturing of the microplastic tracers. The results could inform future studies on how microplastics behave in the environment along with further validating of the use of microplastic tracers.

There are various different experiments that could be established to further the research of microplastic fate and transport. Following a similar experimental method, other salinities and minerals could be tested. Another route would be to investigate microplastic aggregation in various mineral mixtures.

Final Thoughts on my Senior Project

Gaining my own research experience along with learning how to operate ICP-MS has helped tremendously with my educational goals. I have been accepted to the master's program at Southern Illinois University and plan to use ICP-MS on my own research project. The information I was learning in my project often aligned with the information I was learning in my other classes. For example, in one of my courses, we were learning about aggregation. In another course, we had to design our own experimental study. My entire senior project not only helped me further my own knowledge in the toxicology field, but it has also prepared me for my future graduate program.

Citations

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