Investigating the use of plant-derived polymers on the reduction of microplastics in freshwater samples

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Introduction

Plastics have become a staple in humans' daily lives with around 300 billion tons of plastic being produced every year.[3] This leads to both macro and microplastics being deposited in our water sources at an increasing rate. Microplastics are classified as a synthetic solid particle smaller than 1 mm that is insoluble in water.[1]

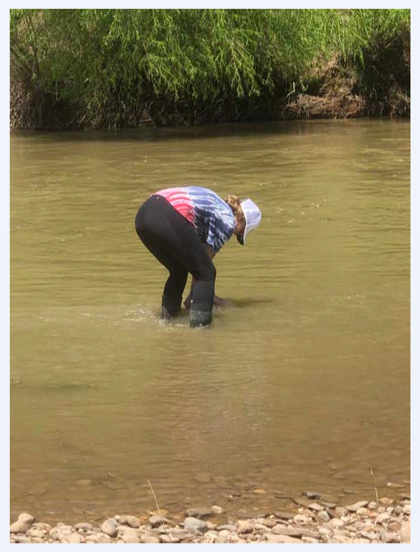
Microplastics have many sources[2]:

- Microbeads from cosmetics, and air blasting
- Degraded macroplastics
- Fibers from textiles

In the past 10 years, microplastics have been found in many of our natural water sources (both fresh and salt) as well as in our treated drinking water. The presence of microplastics in our water is a rising issue for both the environment and humans. Microplastics are potentially harmful to animals and humans due to their composition as a synthetic organic polymer, this allows them to absorb other chemicals in the environment. Some of the toxins known to be found in microplastics are:

- Polychlorinated biphenyls (PCBs)
- Pesticides
- Dioxins
- Flame-retardants
- Other carcinogens

Once microplastics are ingested those toxins can be reabsorbed in the liver of the organism which can lead to liver toxicity and possibly other drastic health issues. Studies have already reported that the ingestion of microplastics has led to liver toxicity in many fish species.[5] Current methods to remove microplastics from water utilize polyacrylamide, a synthetic polymer, which can become carcinogenic as it breaks down after time.[4] To maintain the health of our environment sustainable, eco-friendly water treatment techniques must be researched. The plant-derived polymers used in this experiment are an environmentally friendly and efficient alternative to what's being currently used.



Images 1 and 2 *depict the process of collecting water at the Bosque River (left) and Colorado River (right)*

Objectives

The purpose of this research project is to investigate the use of plant-derived polymers to reduce the number of microplastics in freshwater samples.

Methods

Water Samples were collected from the Bosque River in Stephenville City Park, as well as from the Colorado River at Timberlake Biological Field Station.

- Polymers used: Plant-derived polysaccharides
  - Okra mucilage (okra soaked overnight, manually extracted, and dried)
  - Tamarind seed gum (commercially purchased)
  - Ratios Investigated: (2:1, Okra: Tamarind) & (1:1, Okra: Tamarind)
  - (2:1) Concentrations: 0.9 g/L, 1 g/L, 1.2 g/L, 1.5g/L, and 1.8 g/L
  - (1:1) Concentrations: 0.5 g/L, 1 g/L, 1.5 g/L, and 2 g/L
  - Samples: 500 mL control, 400 mL with 100 mL of polysaccharide for treatment, and 400 mL with 100 mL of polyacrylamide
  - Jar Test: 100 rpm for 1 min, 50 rpm for 5 min, allowed to settle for 5 min, 50 mL was collected at 0, 15, 30, and 60 min

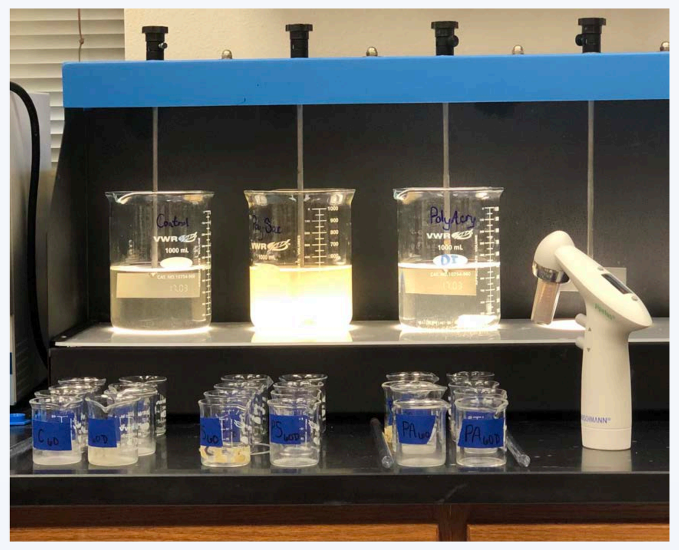


Image 3 *displays a Jar test set up using Colorado River Water.*

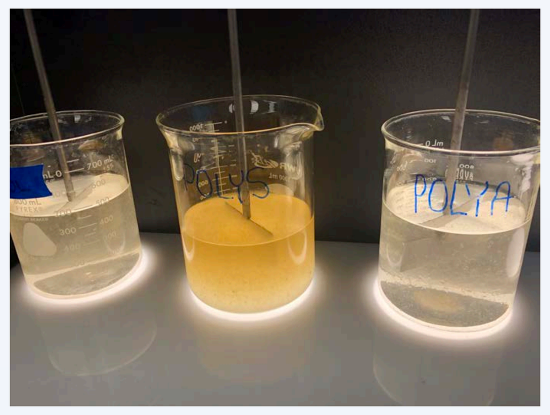
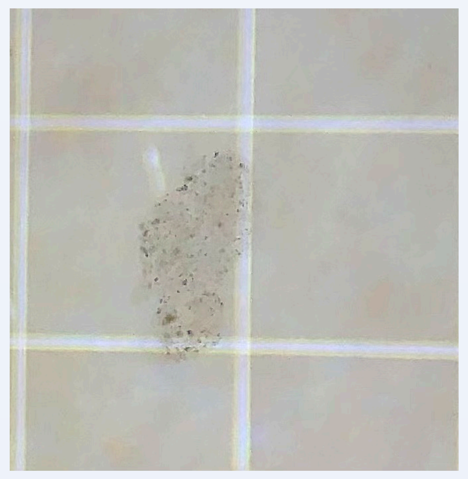


Image 4 *displays a Jar test as it is in the process of stirring.*

Microplastic Removal

- Samples are placed on a hemocytometer and counted using 10x magnification.
- Counts are compared to determine the most efficient time, dosage, and ratio



Images 4 and 5 *display the effect of the polysaccharide on microplastics in water samples*

Results

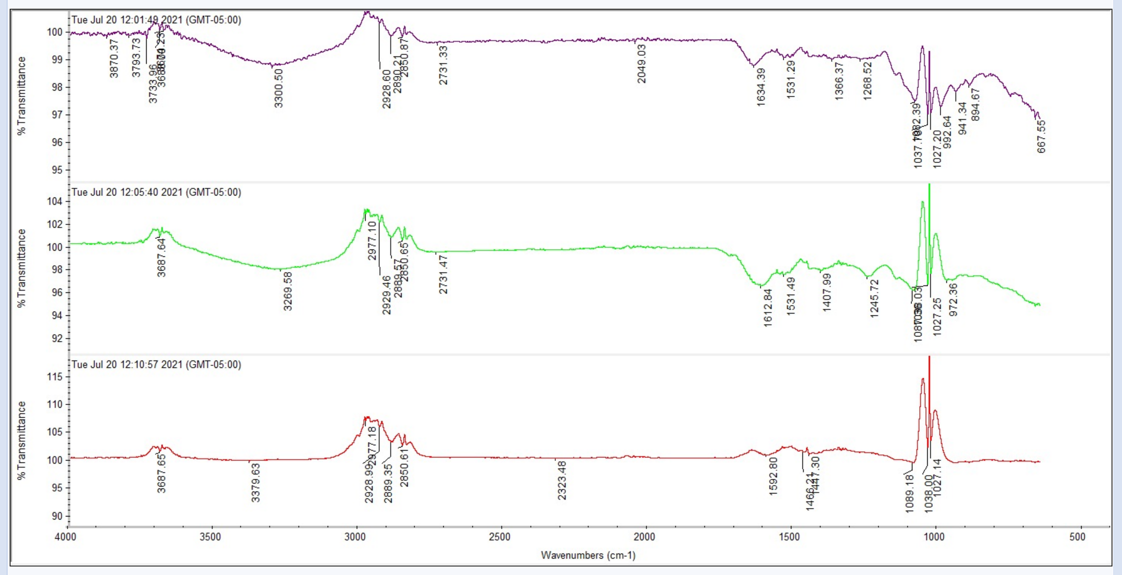


Figure 3: *This FTIR image displays a comparison of the two polysaccharides used and the treated water samples.*

Flocculation

- The 1000 mL, and 50 mL jars were left in the oven overnight to allow flocs to form and dry.
- The flocs were scraped out of the jars and ground into a powder using a mortar and pestle
- The powder was then analyzed using FTIR (Fourier-Transform Infrared Spectroscopy)

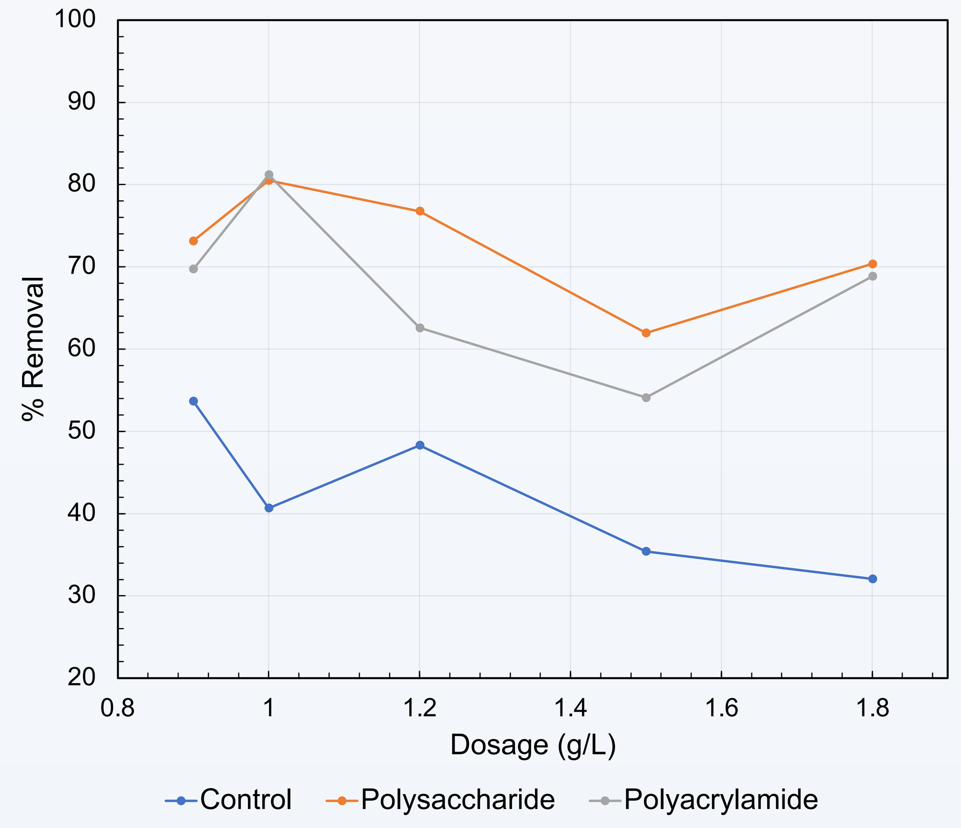


Figure 1: *This graph illustrates the percent removal for the 2:1 (Okra:Tamarind) ratio at varying dosages.*

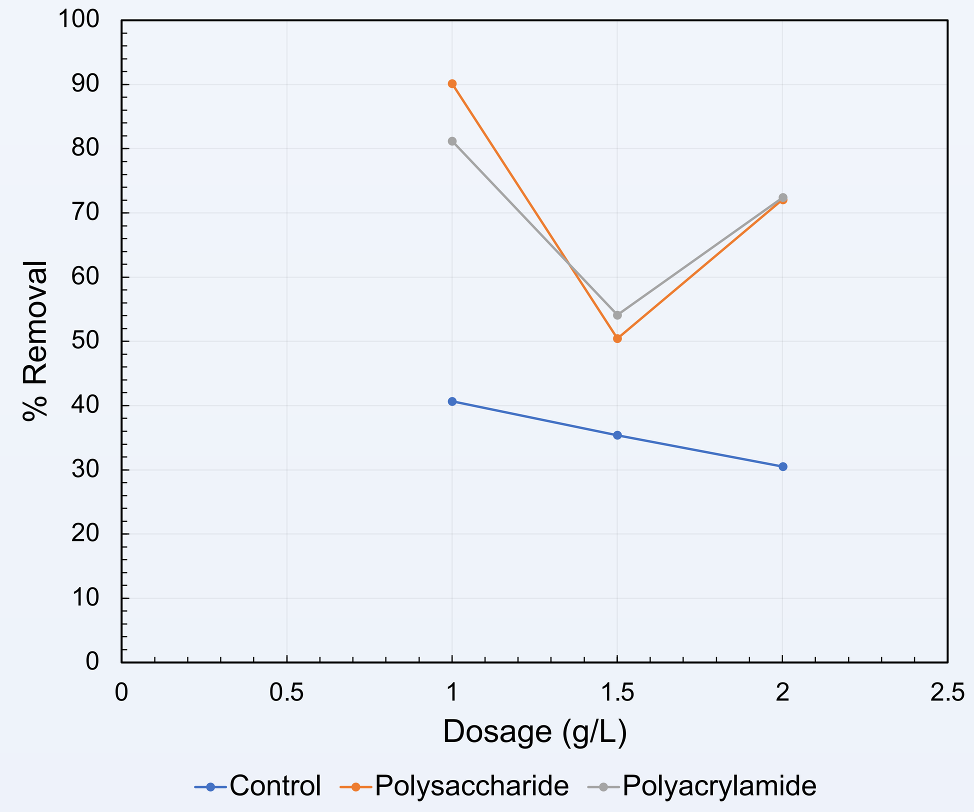


Figure 2: *This graph illustrates the percent removal for the 1:1 (Okra:Tamarind) ratio at varying dosages.*

Results

- The application of the polysaccharide mixtures were successful at reducing microplastics at various dosages in freshwater samples (Figure 1, and Figure 2)
- Both ratios were found to be the most efficient at reducing microplastics at a 1 g/L dosage and a 60-minute time period.
- The 1:1 ratio was found to be more efficient than the 2:1 ratio. With the 2:1 mixture bearing a max removal of 80.52%, and the 1:1 mixture an average max removal of 89.5%. (Figure 2)
- The FTIR in Figure 3 reflects how the polysaccharide mixtures adsorbed contaminants in the treated water. This is shown by the lack of contaminant peaks in the treated water sample.

Image 6 *depicts the process of counting microplastics using a hemocytometer and microscope.*

Conclusions

- Both polysaccharide mixtures used in this experiment successfully reduced the number of microplastics in freshwater samples.
- The 2:1 Okra: Tamarind ratio was found to be the most efficient at a 1 g/L dosage with an average 89.5% removal which is similar but more efficient than that of the commonly used polyacrylamide.
- The naturally derived polymers are an effective alternative to synthetic materials. More experiments must be done to investigate the use of polysaccharides in the treatment of saltwater.

References

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