2023

WWU Research Assistant Intern

Itzel Perez
Wetern Washington University

COLLEGE OF THE ENVIRONMENT

Internship Title: Degradation of Polymers

Organization Worked For: College of the Environment

Student Name: Itzel Perez

Internship Dates: 3/30/23 6/10/23

Faculty Advisor Name Manuel Montaño

Department ESCI

STUDENT SIGNATURE 

DATE: 06/08/23

Degradation of Polymers in the Human Digestive System

Itzel Perez

2-credit Self Design Experiment

The College of Environment, Western Washington University.

Advisor: Manuel Montaño

June 8th 2023

What have you been doing?

My 2-credit research project focused on the degradation of polymers, such as Low-Density Polyethylene and Polycarbonate, within the human digestive system. Throughout my project I had been working with my advisor, Dr. Montaño, as well as my research partner, Ashlynn Lee, to develop an in-depth understanding of polymers. I first began doing research on polymers of interests and narrowed down to two specific plastics- Low-Density Polyethylene (LDPE) and PC (Polycarbonate).

The first few weeks was spent on developing my hypothesis as well as my experimental design. I was interested on how plastics degrade within the human digestive system and how they may impair the body. My investigation was based on the belief that the fluids found within the digestive system will accelerate the degradation of polymers. Furthermore, weathered polymers will degrade much quicker in comparison to nonweathered polymers. To test this theory, we created an experimental design to replicate (as best as we could).

I spent a single day in Dr. Montaño's lab creating two different digestive juices- Saliva and Gastric Juice. There was no previous recipe for these two fluids, however a previous graduate student, Star Summer, had created stimulated gastric juice for their own polymer research. Cross referencing their study as well as Peter, R. et. Al. (2022), I was able to create my unique artificial gastric and artificial saliva. On the same day previously mentioned, I pipetted each fluid into their respective 20ml vials with pieces of cut up polycarbonate and LDPE. A replicate from each fluid and plastic was examined after 4 and 21 days using the Raman Spectrometer.

For the remainder of the quarter, my time was spent using the Raman to find signs of degradation within the polymer of interest. Unfortunately, more than halfway into my experiment, what I thought was LDPE, turned out to be PC. Consequently, with no LDPE pieces on hand, I spent the majority of my Raman analysis focusing on polycarbonate. Using data collected from the Raman, I was able to compare a control of PC with a degraded 'digested' PC.

What have you learned?

The main learning target in this experience was learning how to use a Raman Spectroscopy as well as learning more about polymers. I felt that I learned a lot about polymers as well as how much plastic is in our food and bodies. Most importantly, I learned what types of plastics are typically used in food storage, their structures, and the time it takes for them to degrade within the environment. I learned that a major contributor of micro(nano)plastics (MNPs) is polymers and that they are immune to microbial degrading and so they remain in the soil and in landfills as a semi-permanent residue.[1]

Although I did not end up analyzing it, LDPE was incredibly interesting to me because of how often it used in my everyday life. LDPE is a tough and flexible polymer characterized by long branches that does not pack well into crystals.[7] It is an incomplete crystalline solid with a degree of crystallinity in the 50-60% range.[8] LDPE is unreactive at room temperature but is slowly attack by strong oxidizing agents and some solvents can cause softening or swelling.[8] Due to its versatility it is manufactured in a variety of products such as squeeze bottles, tubing, laboratory equipment, plastic bags, frozen food packaging, etc.. However, it is rarely degraded after disposal and can be found in the environment for 500+ years (surface degradation rate of 3.7 μm $year^{-1}$, m.).[9]

I also got to learn about Raman Spectrometry! This was not a topic that was previously taught to me, so I took the time to watch videos on how Raman spectrometry works. I also worked on my technical and listening skills while being taught the delicate handling of the Raman. This took the majority of my time to learn as the process requires patience, organization, and practice. However, it was super fun to learn how to work the machine and rewarding once I was able to use it without supervision (outside of my Raman partner).

Lastly, although I did not spend much time in the lab, I really got to learn how to work in a lab on my own. I learned that I do not enjoy lab work, but that I do love analyzing things (like on the Raman). This is an important lesson as it has propelled me into studying more data-based science for toxicology.

How did your WWU education prepare you for the work you're doing?

My education at Western Washington University prepared me incredibly well for this project. My courses that have helped me in understanding how to develop and look for research has been Water Quality and Toxicology I. These two courses were writing intensive for me as both required me to spend time reading, synthesizing, and peer reviewing various published papers as well as my peers writings. Water quality and Toxicology I also helped me become a little more confident in the lab.

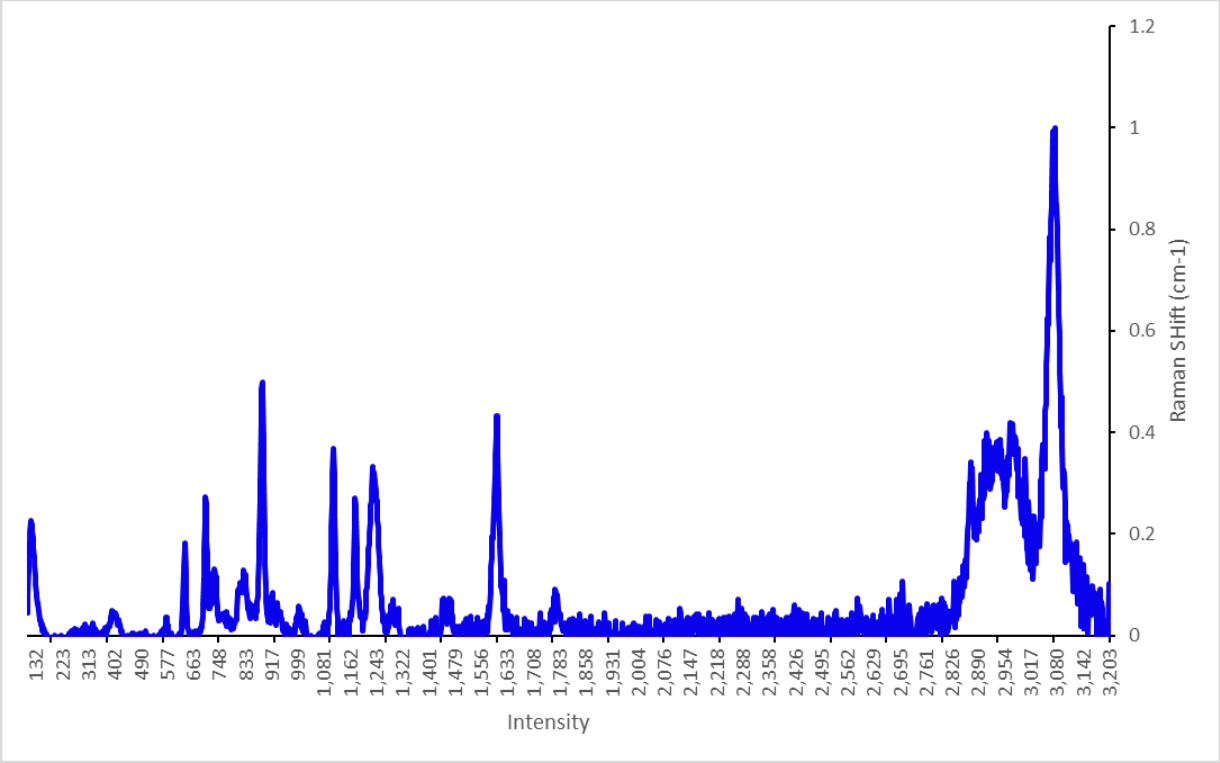
For the research and experimental design, I felt that toxicology I really helped me perfect my self guidance. I used to feel intimidated about having little to no guidance, but Tox I really encouraged me to use critical thinking skills to create my own experiment as well as collect my own resources to develop a plan. Having to read various peer reviewed studies helped me narrow down where to find reliable resources as well as quickly rule out what papers would not be helpful. I also learned quickly that although one study would briefly mention that they used simulated digestive juices, I was able to find the cited resource which gave a detailed explanation of their methods. Something that I previously wouldn't have known to do without the skills I attained with time.

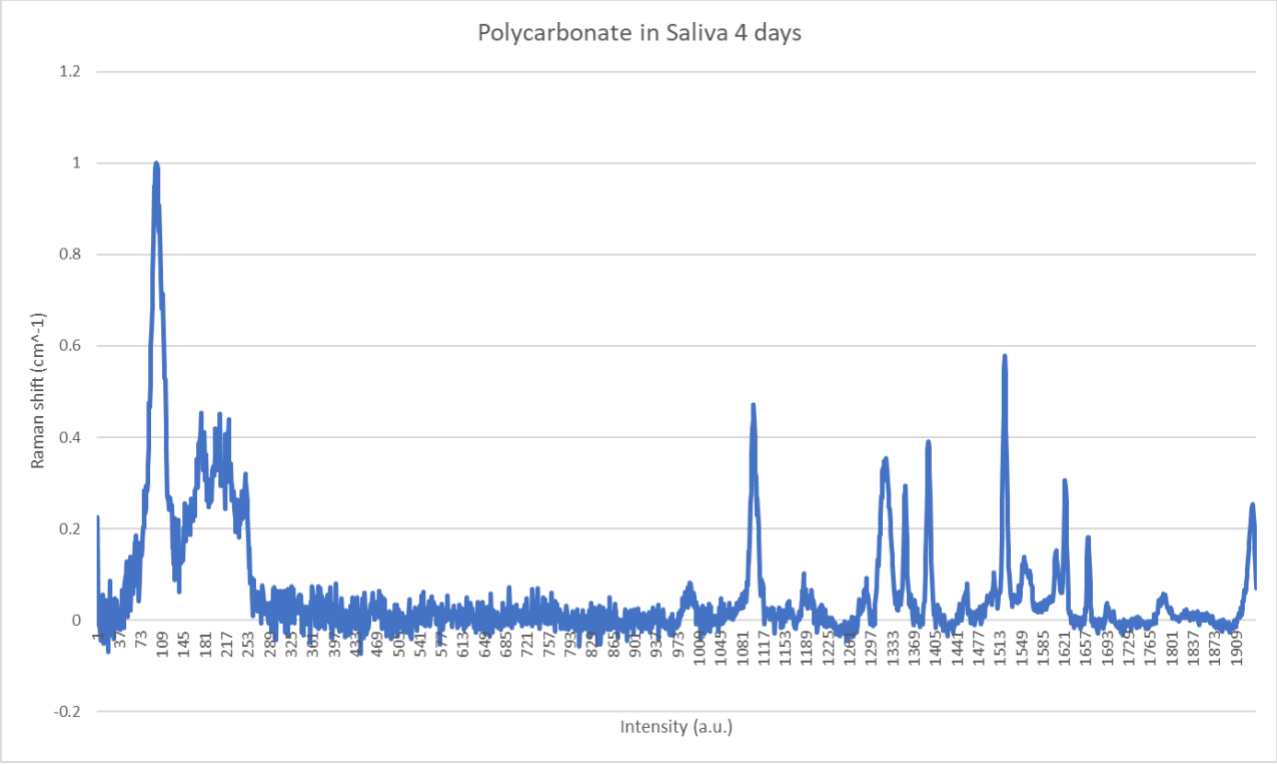
As for the lab and using the Raman, Water Quality (WQ) and Toxicology I lab both helped build my confidence in the lab. Since I had to take chemistry lab over covid, I did not have much experience in the lab prior to these classes. During my time in Tox and WQ, I was taught quickly what each flask, cylinder, tool, etc. was called. I learned how to clean equipment properly as well as what type of compound can be used in specific containers (i.e. metal, glass, or plastic). I was taught how to protect myself and my peers when working in a lab by wearing PPE and always working under the fume hood.

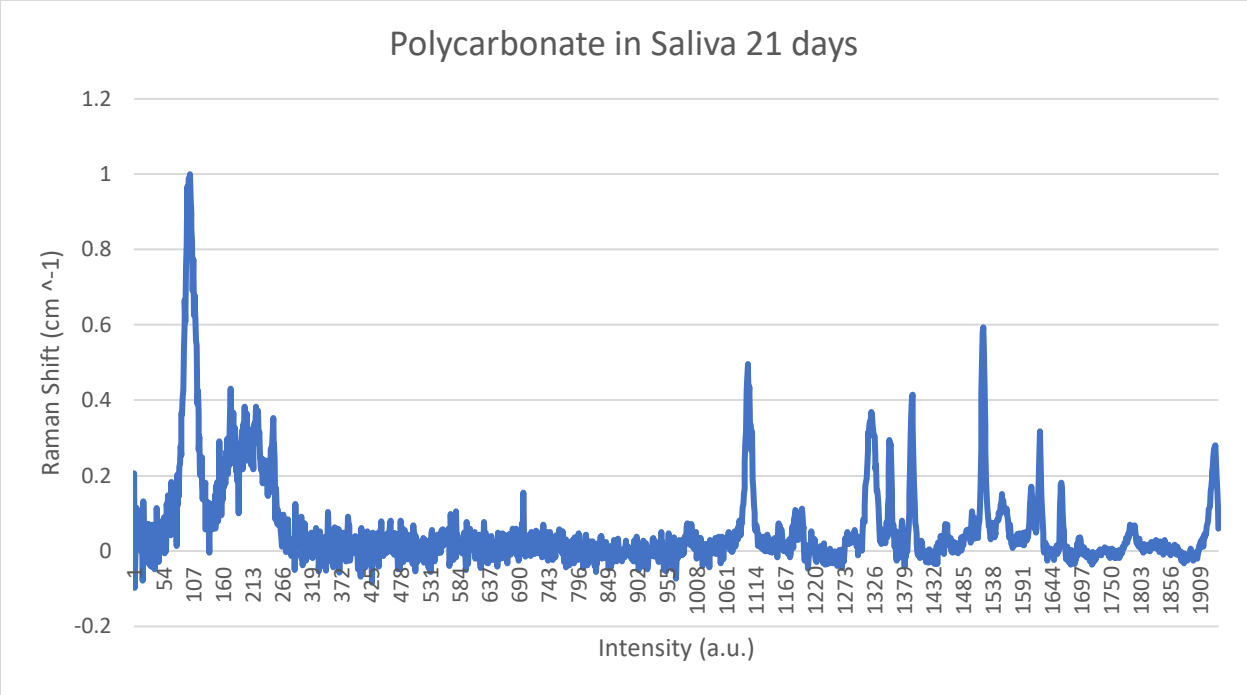
Although these skills may seem like basic skills, they were important in building my confidence within the lab. With my new gain skills in using the Raman spectrometer, I look forward to telling future employers how exciting it was to have

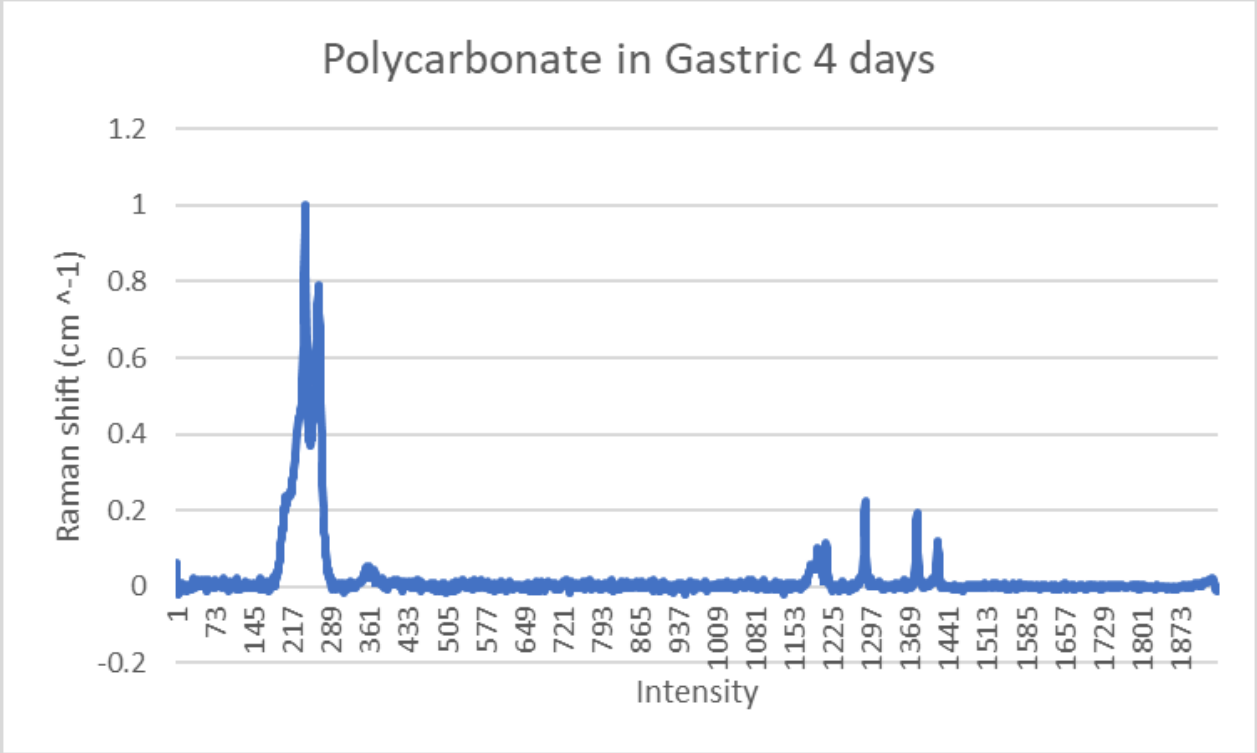
learned to use such a tool and how I utilized it to better understand the degradation of plastics.

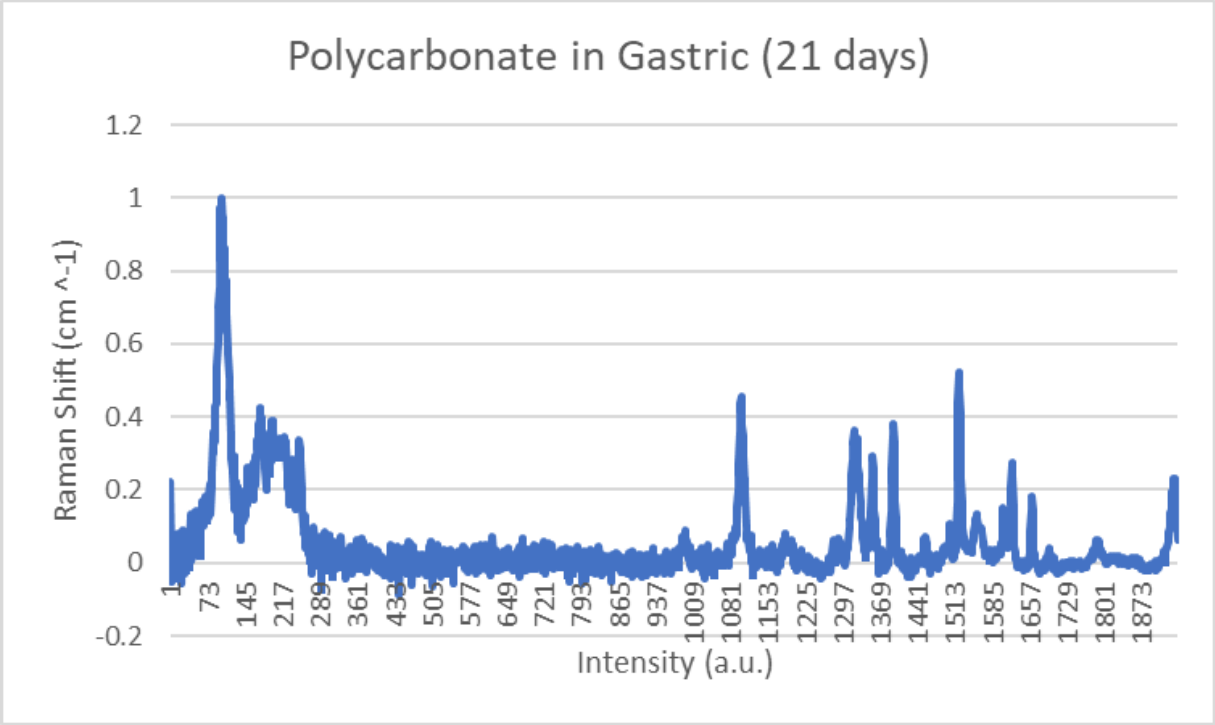
Data (I tried overlapping the data, but Microsoft kept crashing)






Polycarbonate in Saliva 21 days
Raman Shift (cm ^-1)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
1
54
107
160
213
266
319
372
425
478
531
584
637
690
743
796
849
902
955
1008
1061
1114
1167
1220
1273
1326
1379
1432
1485
1538
1591
1644
1697
1750
1803
1856
1909
Intensity (a.u.)


Polycarbonate in Gastric 4 days
Raman shift (cm ^-1)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
1
73
145
217
289
361
433
505
577
649
721
793
865
937
1009
1081
1153
1225
1297
1369
1441
1513
1585
1657
1729
1801
1873
Intensity



Sadly, my excel file would continuously crash whenever I would try to compile a line graph of each fluids time difference. I found it super interesting to see an increase of spikes in the gastric plastic. I believe this signifies a large shift(?) and therefore some losses in the typical compound found inn PC. One thing to note, my plastics went from have a 98% match to 93%. It would be super interesting to see what exactly leaches from these plastics.

References

(1) Longo, C.; Savaris, M.; Zeni, M.; Brandalise, R. N.; Grisa, A. M. C. Degradation Study of Polypropylene (PP) and Bioriented Polypropylene (BOPP) in the Environment. *Mater. Res.* **2011**, *14* (4), 442–448. https://doi.org/10.1590/S1516-14392011005000080.

(2) Vogl, O. POLYPROPYLENE: AN INTRODUCTION. *J. Macromol. Sci. Part A* **1999**, *36* (11), 1547–1559. https://doi.org/10.1081/MA-100101614.

(3) Severini, F.; Gallo, R.; Ipsale, S. Some Aspects of the Environmental Photo-Degradation of LDPE. *Polym. Degrad. Stab.* **1988**, *22* (1), 53–61. https://doi.org/10.1016/0141-3910(88)90056-0.

(4) Koerner, G. R.; Hsuan, Y. G.; Koerner, R. M. The Durability of Geosynthetics. In *Geosynthetics in Civil Engineering*; Elsevier, 2007; pp 36–65. https://doi.org/10.1533/9781845692490.1.36.

(5) Merrington, A. Recycling of Plastics. In *Applied Plastics Engineering Handbook*; Elsevier, 2011; pp 177–192. https://doi.org/10.1016/B978-1-4377-3514-7.10011-X.

(6) Maafa, I. Pyrolysis of Polystyrene Waste: A Review. *Polymers* **2021**, *13* (2), 225. https://doi.org/10.3390/polym13020225.

(7) Jordan, J. L.; Casem, D. T.; Bradley, J. M.; Dwivedi, A. K.; Brown, E. N.; Jordan, C. W. Mechanical Properties of Low Density Polyethylene. *J. Dyn. Behav. Mater.* **2016**, *2* (4), 411–420. https://doi.org/10.1007/s40870-016-0076-0.

(8) Kumar Sen, S.; Raut, S. Microbial Degradation of Low Density Polyethylene (LDPE): A Review. *J. Environ. Chem. Eng.* **2015**, *3* (1), 462–473. https://doi.org/10.1016/j.jece.2015.01.003.

(9) Chamas, A.; Moon, H.; Zheng, J.; Qiu, Y.; Tabassum, T.; Jang, J. H.; Abu-Omar, M.; Scott, S. L.; Suh, S. Degradation Rates of Plastics in the Environment. *ACS Sustain. Chem. Eng.* **2020**, *8* (9), 3494–3511. https://doi.org/10.1021/acssuschemeng.9b06635.

(10) Peters, R.; de Jong, N.; de Haan, L.; Wright, S.; Bouwmeester, H. Release and Intestinal Translocation of Chemicals Associated with Microplastics in an in Vitro Human Gastrointestinal Digestion Model. *Microplastics Nanoplastics* **2022**, *2* (1), 3. https://doi.org/10.1186/s43591-021-00022-y.

(11) Summer, S. Investigation of Nanoparticle Microplastic Analogs for Environmental Assessment.

(12) Sefi-Cyr, H. Impact of Carbonaceous and Inorganic Nanomaterial Chemistry on Polymer Additive Release from Weathered Epoxy Composites.