Final Report delivered to the Okanagan Basin Water Board (OBWB) for the Water Conservation and Quality Improvement Grant Program (WCQI)

May 31, 2022

MICROPLASTICS IN OKANAGAN LAKE

A scoping study to evaluate the presence of microplastics in Okanagan Lake and Kelowna's municipal wastewater

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Executive Summary

The evaluation of *Microplastics in Okanagan Lake* project (OBWB WCQI 2021-2022) was initiated in the Spring of 2021 with the grant commitment from the Okanagan Basin Water Board (OBWB) to FreshWater Life. The overarching goal of this project was to better understand microplastics in Okanagan Lake and inform potential mitigation solutions. This project was set as a scoping study that may inform future monitoring in addition to looking to quantify and *possibly* qualify the presence of microplastics in Okanagan Lake and Kelowna's municipal wastewater.

The core partners of FreshWater Life, Seven in the Ocean and Copper Sky Productions have been actively working with the City of Kelowna, local educational and research institutions of the University of British Columbia Okanagan and Okanagan College (OC), the Okanagan Nation Alliance (ONA), and Fresh Outlook Foundation (collectively the "Partnership"). Under this grant agreement with the OBWB, we have:

1. Confirmed the presence of microplastics in both wastewater and freshwater samples from Okanagan Lake.
2. Established a freshwater and wastewater sampling protocol in alignment with the project goals.
3. Conducted the Okanagan Lake surface water sampling at 5 locations per the grant agreement.
4. Collected both inbound and outbound wastewater samples at the City of Kelowna Wastewater Treatment plan.
5. Collaborated with Okanagan College to develop two capstone projects where students developed analysis protocols for extracting and identifying microplastics from freshwater and wastewater samples.
6. Initiated analysis of samples for microplastics in partnership with Okanagan College.
7. Collected video footage at each of the above steps of the process for the purpose of building the 10-minute video documentary.
8. Secured various social media channels and communicated widely through local and regional media about the results.
9. Produced a 2-minute "project trailer" video.
10. Received final data from Okanagan College.

Final analysis from the Okanagan College WET capstone students confirm that microplastics were present in all five sampled sites on Okanagan Lake, as well as both influent and effluent wastewater from Kelowna's Wastewater Treatment Facility.

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1.0 Introduction

Plastics have transformed the world for humanity: from the goods we consume to the utility and protection of foodstuffs, to healthcare and clothing, to transportation and beauty products and beyond. It can be difficult, if not impossible, to live a truly plastic-free lifestyle, and plastics have become a part of our everyday lives. It is likely that the vast majority of people on the planet have had access to or utilize plastic in their daily lives. Both single-use and recycled plastics are in use globally, and industry is producing and people are consuming it much faster than the environment can break it down.

Unfortunately, most plastics end up in landfills or are inadvertently released into the environment where they can sit for hundreds of years or longer before they are broken down; simply put, plastic is accumulating in the environment. While there are variants of plastics, the most pervasive plastics do not magically disappear, they simply break down into smaller and smaller fragments through biological and photodegradation processes. The smallest of the fragments are designated as microplastics (<5mm in diameter) and can be invisible to the human eye, mistaken for organic debris, or even food for aquatic organisms from invertebrates such as zooplankton, to fish and birds. Functionally, some of the plastic we consume and dispose of today will be present and likely will be detectable in the environment for multiple human generations.

The global evidence and pervasiveness of macro and microplastics in all the world's oceans and freshwater systems indicates that the majority are anthropogenic in origin. We expect that plastic use in the Okanagan follows global patterns of use and disposal, and any plastic pollution in the Okanagan environment would be due to the human population living, working, and visiting the Valley. With the bulk of the population in the Okanagan Valley residing on or close to the Okanagan Lake, and the communities of Vernon at the north end (Kelowna, West Kelowna, Peachland, Summerland and Penticton/Naramata at the south) constituting approximately 250,000 residents that at least partially rely on the Okanagan Lake for their daily water use including the release of wastewater, we hypothesized that plastics have been and are possibly being inadvertently discharged into the Okanagan Lake with uncertain consequences in the short term and long term.

The first step in understanding the consequences of plastics in our environment is confirming that it is indeed present, and if so at what concentration.

1.1 Goals and Objectives

The goal of this project was to quantify and if possible, qualify, the presence of microplastics in Okanagan Lake and the City of Kelowna wastewater.

The objectives of this project were:

1. to determine if microplastics are present and can be detected in Okanagan Lake;
2. if wastewater is a potential source of contamination; and
3. if microplastics are present, determining solutions to mitigating microplastics entering waterways that are achievable and community-oriented.

2.0 Partners and Collaborators

This small scoping study garnered considerable attention on discussion with various active and potential collaborators and partners. The core partners of FreshWater Life, Seven in the Ocean, and CopperSky Productions have been actively working with collaborators from FreshOutlook Foundation, UBCO and the City of Kelowna to meet the terms of the grant agreement.

Since the initiation of the project, we have expanded the Partnership and added additional collaborators that are now involved with the project. The City of Kelowna facilitated safe access to wastewater samples despite the challenges that COVID-19 had created with how the samples are both collected and handled.

The Okanagan Nation Alliance (ONA) Fisheries Program, with ongoing monitoring of fisheries in the Lake, offered their rigid-hull inflatable fisheries vessel and crew to conduct the open water manta trawl.

UBCO was active in the first quarter of this grant cycle, assisting with sampling design, testing the laboratory analyses, and facilitating access to laboratory facilities. However, the graduate student we were working closely with could not delay his departure for his graduate studies to Alberta and became unavailable for the freshwater sample analysis. Additional new, inbound graduate students at UBCO were offered, however, due to onboarding and training delays, we could not guarantee the analysis of water samples before the end of the grant period. Thus, we pivoted to work with Okanagan College to conduct both the wastewater and freshwater sample analysis.

The Okanagan College Water Engineering Technology (WET) program led both the wastewater and freshwater laboratory sample analysis for microplastic through the Fall Term 2021. Two groups of four (4) students, divided into the wastewater and freshwater teams, cooperated with the Partnership to process the samples, and concurrently meet their requirements as a capstone project in compliance with their degree requirements. These eight (8) students completed the sample analyses and reported their findings on the presence of microplastics in both freshwater and wastewater in November 2021 (Figure 1).

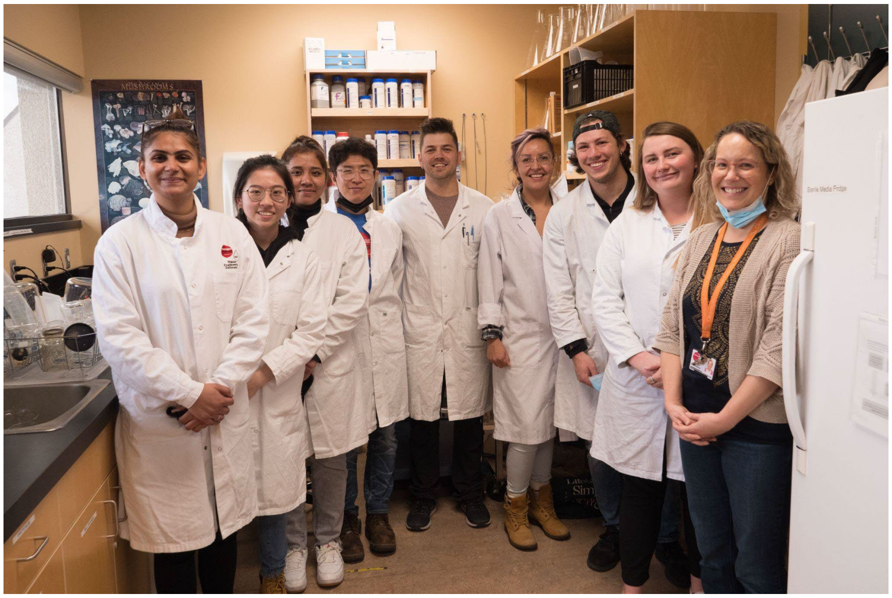

Figure 1. Okanagan College WET Capstone Students focus on Microplastics assessment in Okanagan Lake freshwater and City of Kelowna wastewater. Erin Radomske, OC (right) provided guidance and support.

3.0 Okanagan Lake Microplastics Assessment

3.1 Objectives

We have hypothesized that microplastics of anthropogenic origin have been discharged into Okanagan Lake most likely transported mostly through surface water runoff and from plastics released into the lake via wastewater from daily household activity including dishwashing, laundry, and cosmetics used in daily hygiene care, and other sources. Should microplastics be extant in the lake, we endeavoured to determine if they were detectable in surface water in Okanagan Lake, and focused our sampling in areas where they might predictably be detected if present.

3.2 Methods

Okanagan Lake surface water sampling occurred twice over the month of August 2021: August 5 to test gear and sampling protocols and again on August 25, to collect the official samples. On the first sampling trip, both UBCO (Ryland Giebelhaus) and OC (Erin Radomske) were present to assist with the collection. Following the first trip, all samples were brought to UBCO for analysis and evaluation of methods. No other details will be provided here.

Official samples were stored at OC until capstone students were identified, trained, and initiated sampling in the laboratory.


Figure 2: Manta trawl being towed in Okanagan Lake.

Surface water sampling was completed using a surface manta tow with a 0.335mm mesh net, fitted with a mesh collection bag to collect samples, generally following the 5 Gyres Manta Trawl Protocol (Figure 2). Prior to deploying, the net was checked that all hardware was fastened and secured. The net was towed next to the research vessel for ~30 minutes, on 1 km long transects, with the vessel travelling at a target rate of ~2 knots. Transect length was confirmed by handheld GPS, following test sampling vial checks that showed no more than a 50% visible collection of surface debris in the sample vial.

The collection bag contents were rinsed into a stainless steel bucket, and poured into pre labelled 1-3 glass mason/sample jar.. Each jar was labeled with sample #, time, date, transect #, and location. To prevent bacterial/algae growth, ethanol was added (>10% volume), and the jar placed into a cooler, stored at ambient temperature for transport to Okanagan College.

Each transect sieved ~31,000 litres and reduced the volume of material to fit into 2-3 1L glass mason jars. Total water filtered across all five sample sites was ~ 155,000 litres.

Okanagan Lake Freshwater Sampling Points

We identified five sampling transect points (Figure 3), three of which were hypothesized to have likely higher concentration of microplastics based on their likely origin (wastewater, mouth of Mission Creek), or were concentrating due to natural constriction (W.R. Bennett bridge). Two additional samples were collected at the widest points of the lake south and north of the bridge as general reference sampling points.

Specifically, we sampled at:

a) **Central lake at its widest point, north of the bridg**e: North of the bridge on Okanagan Lake there are numerous commercial ventures including the construction of residential properties and the decommissioning of the Tolko sawmill at the base of Knox Mountain.
b) South side of the **William R. Bennett bridge-crossing**: This represents a natural constriction and likely concentration point of any microplastics that may have been moving with the currents.
c) **Downstream of the Kelowna Wastewater Treatment Facility** near the outfall pipe where micropolastics may have been released.
d) **Mouth of Mission Creek**: Mission Creek is the largest freshwater input flowing into Okanagan lake. Additionally, Mission Creek flows through mixed-use recreational land, parks, farms, and residential neighbourhoods.
e) **Central lake at its widest point, south of the bridge**.

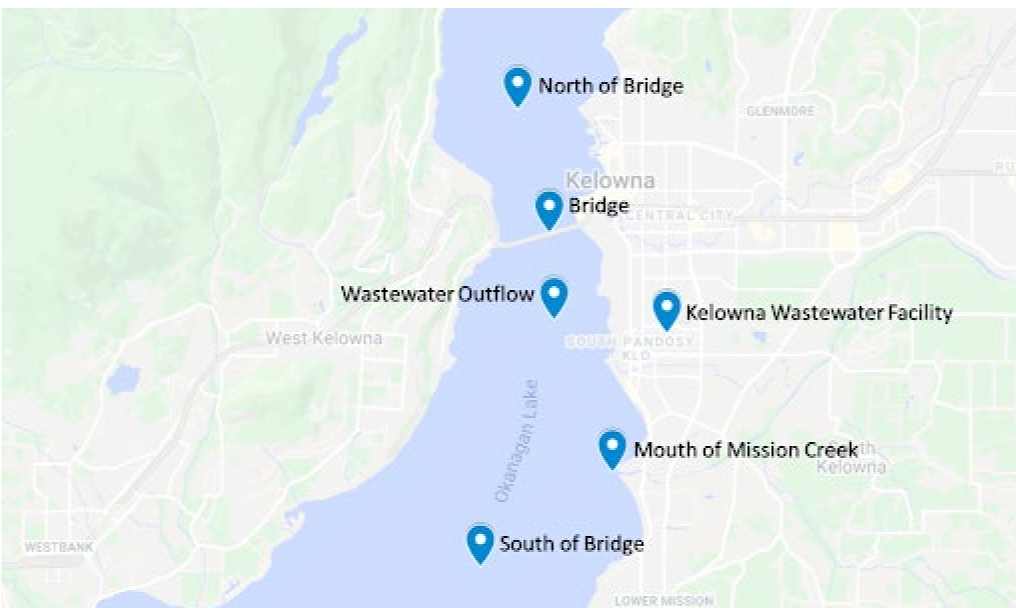

Figure 3: Approximate freshwater sampling locations in Okanagan Lake and at the Kelowna Wastewater Treatment Facility. August/October 2021.

3.3 Summary of Sample Analysis - Okanagan Lake

The freshwater capstone team at Okanagan College developed sampling and analysis protocols for the detection of microplastics based on NOAA's 'Laboratory Methods for the Analysis of Microplastics in the Marine Environment: Recommendations for quantifying synthetic particles in waters and sediments' (NOAA Marine Debris Program 2015) and adapted for the freshwater environment (Figure 4). They concluded that microplastics were present in all five sampled sites on Okanagan Lake. However, their relative concentrations were highly variable. Relative to other freshwater samples, microplastics in Okanagan Lake are quite low (as compared to Lake Superior, Cox et al. 2021). Similarly, relative to marine environments, Okanagan Lake is relatively low as compared to Pacific Ocean and Great Lakes datasets (Eriksen et al. 2013, Moore et al. 2001, Driedger et al. 2015.)

Figure 4: Okanagan Lake freshwater sample at Okanagan College during processing.

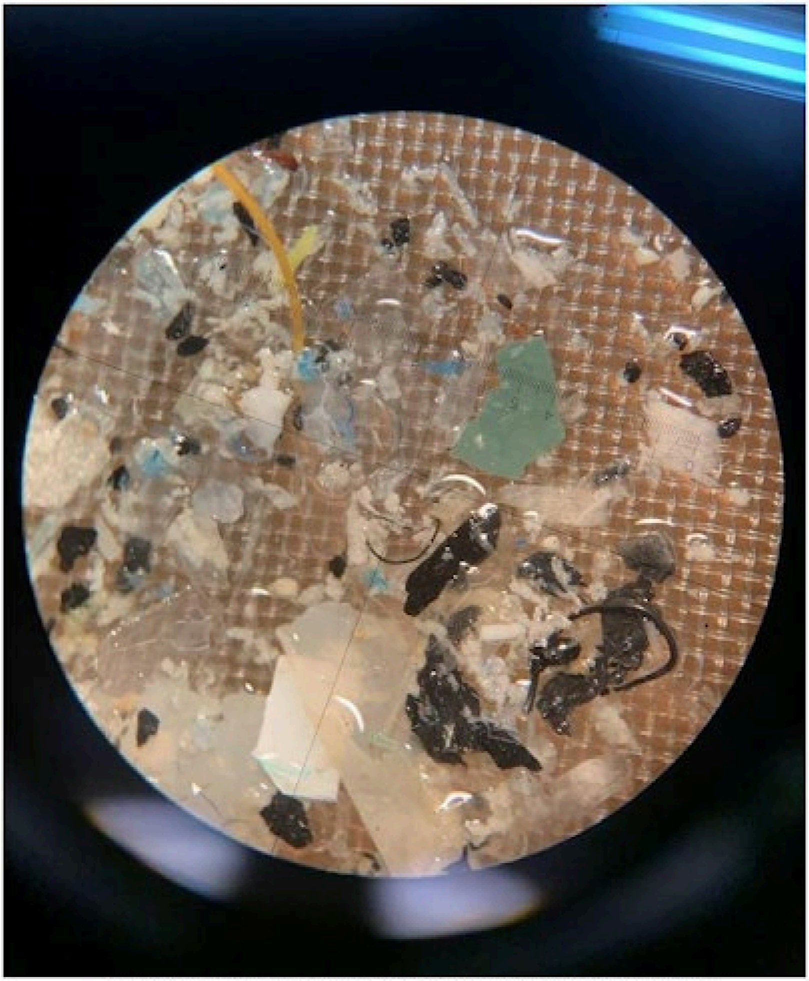

Figure 9: Varying colours and shapes of microplastics post density separation (Photo: J. Sztanko).

Figure 5: Okanagan Lake freshwater sample (Bennett Bridge) post-processing to reveal microplastic particles and suspected tire wear particles in addition to carbon particles from forest fires.

In total, about 2.75 grams of plastic were collected across all five sample locations *(out of a total of 155,000L water filtered across all sample sites).* The greatest concentration of microplastics was collected below the William R. Bennett bridge and yielded 1.1009g.

Microplastic morphology (fragments, fibres, and films) was highly varied, randomized, and did not follow a distinct pattern. However, visual analysis revealed that fragments were the most abundant morphology of microplastic collected, although some fragments mimicked the appearance of fibres. Film-type plastic was the most distinguishable of the samples but least commonly found due to the ease of degradation and resultant varying sizes. Fragments were collected at four of five locations, with abundance being greatest in the area south of the William R. Bennett Bridge. Fibres were collected at all locations, with the greatest abundance appearing in the region of the lake south of the Mission Creek outflow. Films were collected at three of five locations, with the area north of the William R. Bennett Bridge and the area south of it yielding the greatest number of films (Figure 5).

See Appendix A for further details on Okanagan Lake microplastics results.

3.4 Final Deliverables

The Partnership is delivering the following as part of its grant obligations:

1. A succinct, analysis protocol for the collection of and detection of microplastics in lake water samples.
2. Sample results, including the abundance of microplastics per sample and morphology breakdown (i.e., fibres, fragments, and films) (Appendix A and B).

4.0 City of Kelowna Wastewater Microplastics Assessment

4.1 Objective

The City of Kelowna - with the largest concentration of residents in the valley, and its wastewater treatment facility concentrating a large proportion of the resident population's wastewater – was predicted to represent the area with the highest probability of detecting microplastics. Thus, our sampling focused on influent wastewater at the treatment facility (pre-treatment) and effluent wastewater (post-treatment) before discharge into Okanagan Lake.

4.2 Methods

In cooperation with the City of Kelowna, sampling was timed to correspond with daily high water inputs into the treatment facility. This time period was chosen based on when residents were more likely to be at home and using water for laundry, dishwashing, and using hygiene products that may be washed into the sewer system.

The specific step-by-step sampling and analysis protocols were developed in collaboration with the Okanagan College WET program as outlined in Figure 6 and Appendix B.

4.3 Summary of Results- Wastewater

Following similar analysis protocols to the freshwater team, the wastewater team discovered that microplastics were present in both influent and effluent wastewater samples. The wastewater sample analysis was potentially more complex than freshwater samples, with the potential for contamination and false positives (see Appendix B). Regardless of contamination, microplastics were discovered to be extant in both inbound and outbound wastewater samples.

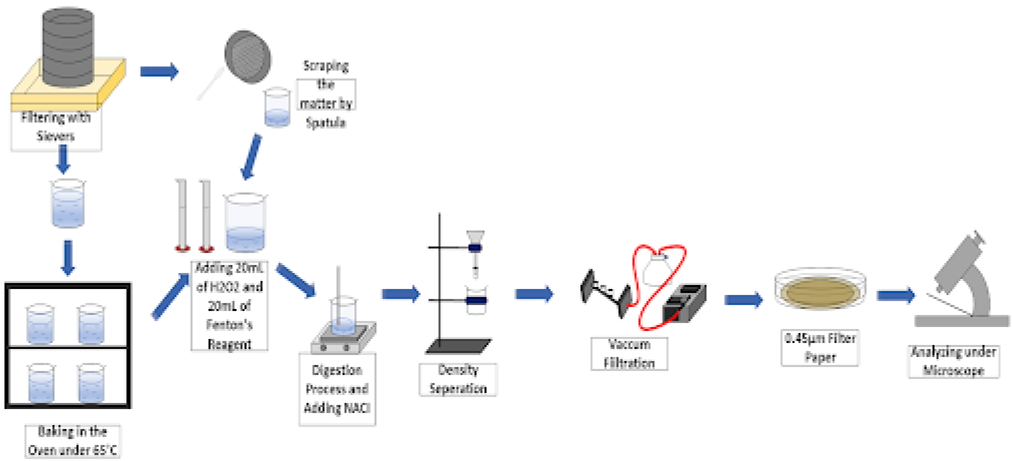

Figure 6: Graphic depiction of sample analysis procedure followed.

Most of the particles recovered in wastewater samples (based on visual observation) appeared to be microfibres (Figure 7). Some plastic films, fragments, and particles that appeared like microbeads were also observed. The most identified colours of the particles were red, blue, black and clear. Other colours observed included yellow, purple, green and pink colours (Appendix B).

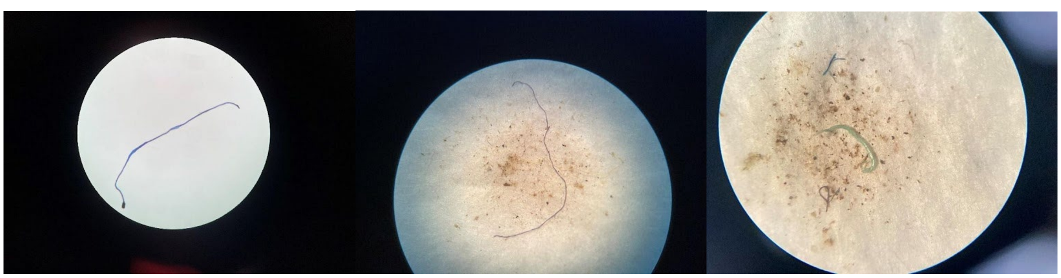

Figure 7: Kelowna municipal wastewater sample, post-processing revealed an abundance of fibres suspected to be microplastics.

4.4 Final Deliverables

The Partnership is delivering the following as part of its grant obligations:

1. A succinct, sampling technique for the collection of wastewater for microplastics; and an analysis protocol for the detection of microplastics (both abundance and morphologies)
2. Sample results, including the abundance of microplastics per sample and morphology breakdown (i.e., fibres, fragments, and films)

5.0 Communications

5.1 Objectives

The purpose of developing communication materials is to raise awareness about the project and generally, to shed light on the topic of microplastics in the Okanagan. These communication materials intend to connect the community with the larger, global context of plastic pollution in a way that is inclusive, transparent and invites inquiry and dialogue (and that does not stoke fear).

5.2 Communication Channels

A project website has been established (https://microplasticsokanagan.com/) to house information about the project, the project team, findings, and related research that ties this work to the global issue of microplastics. Similarly, social media channels have been set up on Facebook, Instagram, and Twitter, to engage with the general public through creative infographics, photos, and written stories. Through these channels, the team can report on project findings, connect with similar groups and interested individuals, and cross-post similar content from project partners and others.

Channel URLs:
Facebook: https://www.facebook.com/microplasticsokanagan
Twitter: https://twitter.com/MicroplasticOK
Instagram: https://www.instagram.com/microplasticsokanagan/

Video and still photography footage were captured along the way for use in the project trailer and forthcoming documentary film that will summarize this project's story. The still photography has been used on the website and has also been used across social media platforms and in press releases by both the project team, its partners, and media outlets. This effectively stretches the use of visual media across multiple channels and sectors.

In conjunction with World Water Day on March 22, the project team and its partners launched a joint press release about the project and its initial findings to the public. The release attracted a sizeable amount of media attention, including:

Interviews

- Daybreak South with Chris Walker: A group of researchers in the Okanagan have found microplastics in Okanagan lake

News Articles

- Global News: Microplastics found in Okanagan Lake, researchers say
- OC News: Community collaboration studies microplastics in Okanagan Lake
- Castanet: Relatively low levels of microplastics detected in Okanagan Lake, Kelowna wastewater
- Kelowna Capital News: Microplastics research being conducted in Okanagan Lake
- Infotel: iN VIDEO: Warning issued about microplastics found in Okanagan Lake
- The Golden Star: Microplastics research being conducted in Okanagan Lake

- Kelowna Daily Courier: Microplastics found in Okanagan Lake
- Kelowna Now: Research reveals presence of microplastics in Okanagan Lake

Videos

- Kelowna10: WATCH: Do microplastics pose a risk to Okanagan Lake?

The Partnership produced a short, two-minute trailer to promote the project and raise interest in and awareness of microplastic pollution in freshwater ecosystems - specifically in Okanagan Lake. As of this writing, the video has received 925 views on Vimeo, 57 views on the Okanagan College YouTube channel, and 4,131 views on Instagram with 21 shares on the platform.

The project trailer can be viewed here: https://vimeo.com/641263640

5.5 Final Deliverables

The Partnership is delivering the following as part of its grant obligations:

1. An online presence.
2. Digital infographics
3. Digital assets include press releases, newsletters, blogs, and social media posts.

The communication aspect of this project will likely be ongoing into the future as it continues into the next and future phases.

6.0 Budget

The project was budgeted at approximately $56,000, with $22,000 committed from the OBWB. To date we have secured approximately $37,000 of in-kind support from UBCO, Okanagan College, the Okanagan Nation Alliance, and FreshWater Life. No additional cash commitments were identified.

The expenses were spent on project management, supplies (sample collection and laboratory analysis), and equipment (the Manta Trawl, see Sampling Details).

The Partnership will continue to secure outside funding from a variety of supporters to produce a finished video product for use as an educational tool and inspirational piece of content. The format for this video product is to be determined (i.e., mini-documentary; docu-series; feature-length documentary, etc).

A detailed summary of the budget and expenses was provided to the OBWB in line with their reporting requirements, and available on request.

7.0 Future Activities

We anticipate that the Okanagan College WET students will complete and report out on the water sample analyses by mid-December 2021. Inevitably we expect the results of the analyses will catalyze additional questions about the significance of the results, the limits of the sampling, in addition to making recommendations to overcome the challenges faced in the laboratory analysis.

In 2022, the Partnership proposes to:

1. Form a Technical Advisory Group (TAG) that can advise the Partnership on the significance of the results, offer guidance on improving both field sampling and laboratory analysis, and potential future water sampling such as in the water column, sediment layer, and potentially in other lakes in the Okanagan Valley.
2. Based on input from the TAG, finalize protocols for future sampling and analysis.
3. Complete the 10-minute video production.
4. Coordinate with the OBWB and other partners in media outreach and communication with the people of the Okanagan Valley writ large.
5. Initiate a longer communication strategy.

8.0 Literature Cited

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5 Gyres Manta Trawl Protocol - 'Manta Trawl Trawlshare Protocols' (no date).

9.0 Acknowledgements

The Project team wishes to thank the following organizations and individuals for their time, commitments, and energies to date:

Okanagan Basin Water Board & the WCQI Grant Program
Okanagan Nation Alliance: Sam Pham, Dave Tom (Vessel Operator)
City of Kelowna: Ed Hoppe, Jen Anderson
Okanagan College: Erin Radomske, Allison O'Neill, David Teasdale, Frank Carey, and WET Capstone Students & Lab Techs:

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Quinn Dartnell
Megahan McCreight
Joshua Sztanko
Tejveer Kaur
Harjit Kaur
Jongsun Park
Shu Ying Sai
Cascade Tong and Isabelle Curyk (Bio/Chem lab tech)
Michelle Toftland (WET lab tech)

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Fresh Outlook Foundation: Joanne De Vries
5 Gyres: Dr. Marcus Eriksen
Institute for Underwater Research (IFUR): Raphael Nowak

10.0 Appendices

Two Appendices follow:

Appendix A: Microplastics in Okanagan Lake: A Qualitative and Quantitative Analysis (freshwater results)

Appendix B: Microplastics in wastewater capstone project report

2021

Microplastics in Okanagan Lake

A Qualitative and Quantitative Analysis

Cosford, W., Dartnell, Q., McCreight, M., Sztanko, J.
MICROPLASTICS OC

Contents

1 Introduction

1.1 Purpose

Okanagan College's Water Engineering Technology (WET) department was contacted by the Microplastics Okanagan group to aid in performing services to confirm the detection of microplastics in Okanagan Lake, British Columbia. MICROPLASTICS OC was hired to conduct qualitative and quantitative analysis on collected lake samples sourced strictly from the surface of the epilimnion layer. A summative report provides detailed analytical results, **hypotheses conclusions**, and a brief discussion on conducting further analysis in meeting the desired criteria outlined by F. Carey, and by extension Microplastics Okanagan.

1.2 Background

Microplastics are commonly defined as man-made plastic items with size less than 5 mm. Having emerged as a significant concern to aquatic environments, minimal research has been conducted to fully understand the degree of distribution and subsequent impact of inland freshwater ecosystems. Alarmingly, freshwater studies of microplastics only began in 2010, long after substantial evidence confirmed chemicals leach from degrading plastics (Andersen et al, 2016). Carcinogenesis, immune system alterations, and bioaccumulation within organisms are known effects from this leachate. Aquatic biota, and by extension the aquatic food web, have shown evidence of plastic pollutants when microplastics have been introduced into an environment through primary and secondary sources (Tirkey & Upadhyay, 2021). Consumed by lower trophic level organisms, degraded microplastic particles are transferred through the food chain via food sources such as algae, zooplankton, and fish, showing evidence of bioaccumulation at each trophic level (Tirkey & Upadhyay, 2021)

Scientific evidence, analytical data, and overall research of this concern has been limited in conductance but is increasingly becoming a priority around the world, and locally in the Okanagan Valley. It is estimated that in a water body, 1% of plastic will be found at the surface, 14% found in suspension, and 85% found within the base sediments (G. Howald, personal communication Sept 23, 2021). Microplastics Okanagan presented a hypothesis that microplastics of anthropogenic origin will be found in Okanagan Lake and would like to initiate a project with the sponsored partners to confirm so, with Okanagan College offering analytical assistance from the WET department. The project aimed to confirm the presence of microplastics within Okanagan Lake, and if microplastics were found, analysis on the morphology of collected samples and their proposed sources of pollution would be provided. To test the hypothesis, surface water (within 1m depth) was collected from five locations in the central region of Okanagan Lake. The central area of this large inland lake is bordered by the City of Kelowna, City of West Kelowna, Westbank First Nation; all of these communities reside on the unceded land of the Syilx (Okanagan) Nation people. Collection techniques included bulk water collection and a surface trawler (Manta) to collect filtered samples with sizes between 350um and 5mm.

Microplastics of anthropogenic origin within Okanagan Lake are a concern and likely transported to the water body via surface water runoff, wind deposit, or treated wastewater from household activity. Large pieces of hard plastic that have since fragmented to smaller pieces of plastic, plastic film, and fibres from synthetic clothing are all classified as secondary sources of microplastic introduction to aquatic ecosystems (Tirkey & Uphadyay, 2021).

The Okanagan Valley's high population density, increasing population, and high residence time of water within its water bodies made Okanagan Lake a desirable location to study microplastics. Three urban centers of Vernon, Kelowna, and Penticton reside on the north, central, and south regions of the lake respectively. Furthermore, highway roads sit adjacent to shores and a bridge traverses the central span of the lake. Okanagan Lake extends 150km in length, averages 5km in width, and is 200m in depth, which results in having a residence time of 60 years (Nowak et al, 2020). Factoring these parameters, the region of the lake near Kelowna demonstrated to be an area with the highest probability of detecting microplastics due to the increased potential contributors of microplastics. As such, our sampling focused on surface waters in five locations (Figure 1), listed north to south:

1. North of William R. Bennett bridge
2. At the William R. Bennett bridge itself
3. Delta of Mission Creek
4. Above Kelowna Wastewater Treatment Plant outfall location
5. South of Mission Creek outflow

1.3 Objective(s)

The primary objective of this project was to determine if microplastics of anthropogenic sources are present in Okanagan Lake. Should this prospect be confirmed, a secondary objective would be to analyze the morphological properties of the collected microplastics in efforts to estimate a concentration amount for the entire surface area of Okanagan Lake.

Methods established by Masura et al. (2015) were used to digest organic materials from the collected sample in efforts to isolate plastic particulate. Visual identification was employed to determine morphology characteristics. The project also aimed to develop methods of detection, isolation, and classification that can be applied specifically to the Okanagan Valley lakes for continued monitoring of microplastics pollution.

2 Project Overview

2.1 Scope

The scope of this project involved identifying the presence of microplastics in collected surface water samples of Okanagan Lake. A viable method to isolate microplastics from organics was determined for accurate qualification and quantification analysis. Recovered microplastics will be separated into fibres, films, and fragments for a representation of morphology. Separated samples were collectively measured and weighed to determine sizes of microplastics present and total mass of each type at each location. As no agreed definition of microplastics is maintained among the scientific community, plastic solids in sizes less than five millimeters were considered micro for this project.

2.2 Milestone Schedule

Project Inception	September 8, 2021
RFP Submitted	September 20, 2021
Project Charter Outlined	October 4, 2021
Gantt Chart & High-Level Report Provided	November 1, 2021
Report Submission & Presentation Walkthrough	December 2, 2021
Report Presentation	December 3, 2021

2.3 Key Assumptions

Microplastics OC assumed the following for project completion:

Okanagan Lake is thermally stratified	No seasonal mixing of lake layers ensuring true surface layer representation while sampling
Laboratory use	Adequate space provided to conduct laboratory specific chemical activities
Available supplies	All supplies have been obtained, available and ready to use
Customer approval	Customer satisfaction with proposal and permission to undertake project
Microplastic confirmation	Detection of microplastic particulates within lake samples

2.4 Constraints

Microplastics OC recognized the following as constraints to successful project completion:

Plastic Size	Plastics from collected samples may be insufficient or exceed the desired analytical size
Laboratory Time	Availability of laboratory space is restricted by occupying classes & programs
NOAA Analytical Method	Potential shortfalls as no concrete, standard, analytical method has been determined for freshwater

2.5 Funding

Funding for the project has been secured through Microplastics Okanagan, Okanagan College, the Water Engineering Technology department, and the Okanagan Basin Water Board. Further sponsorship has been brought to the project, provided through other resources contributed by the Okanagan Nation Alliance, the City of Kelowna, Fresh Outlook Foundation, and the Institute for Underwater Research.

2.6 Laboratory Usage

Laboratory space and time was provided by the Biology Department of Okanagan College, utilizing rooms C376, C376A and C380 for digestion and sample sorting. Time spent in the laboratory was overseen by Erin Radomske.

2.7 Budget

The following materials were required equipment for analysis and their respective costs:

Hydrogen Peroxide	$80.00
Rubber Tubing	$20.00
Stainless-steel Sieves	$98.00
Glass Funnels	$150.00
Table Salt	$5.00
Tube fittings	$30.00
Proposed Total Cost	**$283.00**

2.8 Project Goals

The project aimed to fulfill the hypothesis that microplastics would be found within Okanagan Lake. The project also aimed to establish morphological features of found microplastics. As microplastics research had been focused on detection in marine waters, developing a suitable experimental method for freshwater was also a required task.

3 Sample Collection

Surface water samples were collected from Okanagan Lake on August 25, 2021. Five locations were identified, with one sample being obtained from each location. Sample locations were marked as waypoints and recorded via GPS device. Once in the identified area, a constructed collection device – the Manta Trawl – was deployed in each location and trawled for a time span of 30 minutes. In total, 155, 000L passed through the Manta, over total distance of 5.3km. The Manta trawler is an aluminum crafted device designed to skim along the surface of a water body (Figure 2). Spanning 1575 mm, two stabilizing wings straddle an opening of 570 mm in width, of which a conical net of 1640 mm in length tapers to a collection unit used to capture floating particulate (Figure 3). Collected particulate is contained in a 280 mm long receptacle. The Manta was towed via a boom extending from the port or starboard side of the boat at a speed of 1.8 to 3 knots, in order to reduce any potential wake interference. The Manta netting was rinsed to the conical ending, capturing all particulate in a mesh collection bag. Contents from the collection bag were transferred to glass mason jars labelled with the time, date, and respective sample location. Samples were preserved with a 95% ethanol solution, diluted to 70%, and subsequently stored in a cooler to ensure moderate temperatures were held.

3.1 Sample Locations

Sample locations and their determining factors are outlined below (*see Figure 1 for map)*:

1. North of William R Bennett Bridge
   - No lat/long data obtained
   - Adjacent to city, mid-lake
   - Trawl length of 955m
   - 27,653 L filtered

North of the bridge, the widest area in close proximity to Kelowna's urban center was elected. Numerous commercial ventures, residential construction, and the Tolko sawmill decommissioning process can be considered potential sources of microplasticsa.

2. At the William R. Bennett Bridge
   - 49 deg. 52.652’
     115 dg 30.175’
   - Trawl length of 1100m
   - 31,851 L filtered

The bridge crosses at the narrowest point of the lake, providing a natural concentration point of any microplastics moving south with the current. Additionally, the constant road traffic and tire degradation can be considered.

3. Mission Creek Delta
   - 49 deg. 51.075’
     115deg 30.162’
   - Trawl length of 1100m
   - 31851 L

Mission Creek is the largest tributary to Okanagan Lake. Flowing through mixed use recreational, agricultural, and urban environments, Mission Creek is hypothesized as a carrying body to deposit microplastics in the lake.

4. Above Kelowna WWTP Outfall Location

- 49 deg. 50.643'
  119 deg 29.892'
- Trawl length of 1200m
- 34,742 L filtered

Analysis will allow determination in observing whether microplastics are efficiently removed in the wastewater treatment process.

5. South of Mission Creek Outflow

- 49 deg. 48.678'
  119 deg 33.050'
- Trawl length of 965m
- 27,942 L filtered

South of the bridge, the widest area in close proximity to Kelowna's southern urban center. Deposits from Mission Creek tend to flow south to areas with increased agricultural, residential, and recreationally used land.

3.2 Sampling Methods in Open Water Locations

Samples collected from areas in the center of the lake were obtained by towing the Manta device. The open mouth of the Manta permitted water to flow through the device and collect in the attached conical netting. As a result, particulate smaller than 355µm in size were not evaluated in this project. Once collection was completed, the concentrated sample was rinsed from the mesh with bottled water and collected into 500mL glass mason jars. 95% ethanol (diluted to 70%) was added to the samples to prevent algae growth and preserve organic material until it could be analyzed in a laboratory environment. Field blanks consuming the bottled water used for rinsing was also collected into mason jars, with further analysis being conducted in a laboratory.

3.3 In-Situ Sampling at Mission Creek Delta

Mission Creek was selected as a sample location due to being the largest tributary to Okanagan Lake. Through its reach, Mission Creek flows through many agricultural, commercial, and residential locations from Grey Stokes Provincial Park to Okanagan Lake. Passing through so many environments and depositing into a basin makes the outflow area an ideal sample site. Due to the morphology of Mission Creek, dynamic collection methods were not feasible and as such, a stationary sample method was employed. The Manta device was anchored to a stationary point at a measured distance from the mouth of the creek in a direction allowing the creek outflow to pass freely through the mouth opening and into the netting. Prudence was made to ensure collection occurred after a rainfall event, so as to include runoff waters from the lands bordering the entirety of Mission Creek.

3.4 Supplies and Equipment Needed for Sample Collection

- Manta trawler
- Boat with digital speedometer to ensure consistent trawling speed
- 500mL glass Mason jars
- 95% Ethanol
- Deionized water (preferred)
- Metal spoon & tweezers

4 Experimental Design & Procedure

4.1 Preliminary Design & Spike Sample Testing

A spike sample is a known concentration of specific analytes that are been added to a constructed sample, intended to mimic the properties of the original sample in areas such as analyte volume and concentration. The spike sample was created using the outlined morphologies of microplastics: fibres, films, and fragments. Contents of the spike sample included:

- Ziploc sandwich bags; cut into strips
- Ziploc freezer bags; cut into strips
- Saran wrap; cut into strips
- Biodegradable dog waste bags; cut into strips
- Plastic food containers; cut into strips & pieces of various shapes
- Polypropylene rope; cut and individual fibres separated
- Glitter; already dispersed in minute sizes & shapes

Plastics used in construction of the spike sample were cut to pieces with scissors and further emulsified in an Oasis™ blender to ensure as close a match to the original sample as possible. Once particulates were degraded to an appropriate size, they were collectively added to a 1500mL Mason jar and subsequently filled with deionized water (from Okanagan College's deionized water distribution system).

The spike sample was sieved through a Tyler sieve of 150 µm to separate the particulate from the solution. The particulate obtained was placed into a Despatch Solid Drying Oven under observation from the Civil Engineering Department at Okanagan College and dried for a time of five hours at 40 °C. After drying, the particulate was scattered into the top of a series of sieves, starting with the largest pore size of 4.75 mm and traveled to a base pore size of 300 µm (Figure 4). Sifting was done mechanically using a Rotary Sifter for 20 minutes, resulting in particulates separated by the various pore sizes of the sieve series.

The spike sample ultimately revealed that the applications applied were designed for larger sizes of degraded plastics beyond the limits of this project and as such, other methods of evaluation required investigation.

4.2 Laboratory Requirements & Set-Up

Apparatus and Materials for Digestion

- 500mL & 800mL glass beakers
- Analytical balance (precise to 0.1mg)
- Metal spatula
- Standard Metal Forceps
- Stir Bar
- Watch Glass
- Hot Plate
- Bottle of deionized water
- 30% H_2O_2
- Graduated cylinder
- Tyler sieve 355 µm mesh size
- Custom-made sieves (cut slices of polyvinylchloride [PVC] pipe 75mm x 25mm with an adhesive to attach 0.300mm pore size mesh to end)
- Fenton Reagent Solution [0.05 M Fe(II) solution] (7.5g $FeSO_4 \cdot 7 H_2O$ to 500mL of deionized water + 3mL concentrated sulphuric acid)
- Sodium chloride (commercial table salt is sufficient)
- Alcohol thermometer

Apparatus and Materials for Density Separation

- Retort Stand
- O-Ring clamp
- Spring Clamp (2-inch)
- Aluminum Foil/Watch Glass
- 122mm diameter glass funnel with 50mm of latex tubing attached to funnel stem
- Tubing pinch clamps
- 4-mL glass vials

4.3 Experimental Procedure

The collected samples were filtered though a 355 µm Tyler sieve and rinsed with deionized water, cleaning the particulate retained on the sieve and transferred to a beaker. Once added to the beaker, Fenton's Reagent and H_2O_2 are added to create a Wet Peroxide Oxidation reaction, oxidizing present organics. Salt was then added to alter the density of the solution and poured into funnels to settle. After 24 hours, settled solids were drained off and the rest of the solution again passed through a filter. Once dry, microplastics were analyzed under microscope.

A. Pre-digestion Sieve
    1. Pass collected samples through 355 µm sieve to concentrate collected organic and inorganic particulate
    2. Rinse collected concentrate to remove any particulates less than 355 µm in size
    3. Deposit concentrated sample into beaker

B. Digestion of Organic Material – Wet Peroxide Oxidation [WPO] (Masura et al., 2015)
    1. Add 20mL of Fenton Reagent solution to beaker
    2. Add 20mL of 30% H_2O_2 [CAUTION: solution can boil violently if heated over 75°C]
    3. Let reaction occur on stationary surface at room temperature for five minutes before proceeding with subsequent steps (Figure 5)
    4. Add magnetic stir bar to beaker and cover with a watch glass
    5. With stir function on, heat beaker on hot plate 70°C to 75°C, monitoring via thermometer. If boiling occurs, proceed with one of the following:
        i. Remove from heat and place under fume hood until reaction reduces in intensity
        ii. If reaction has potential to overflow beaker, addition of deionized water will slow the reaction
        iii. Ice bath for emergency temperature reduction
    6. Maintain heat range of 70°C to 75°C for 30 minutes
    7. If natural organic material is visible, add and additional 20mL of H_2O_2
    8. Repeat steps G & H until no organic material is visible (Figure 5)

C. Density Separation
    1. Add 6g NaCl for every 20mL of digested sample as a means to alter the density of the aqueous solution (~5.0 M NaCl)
    2. Return sample to 75°C while stirring, ensuring all salt has dissolved
    3. Pour WPO solution into funnel of density separation apparatus (Figures 6 & 7)
    4. Rinse WPO beaker with deionized water to transfer all remaining solids to density separation apparatus
    5. Cover funnel with a watch glass
    6. Allow solids to settle for 24 hours

D. Final Sample Filtration
    1. After density separation has completed, inspect settled solids in funnel stem for evidence of microplastics. If present in solids, drain from separator and remove microplastics with forceps
    2. Drain any remaining settled solids from separation apparatus and discard
    3. Drain funnel solution through constructed 300 µm pore size sieve to collect any floating solids

4. Rinse funnel & apparatus with deionized water to ensure all solids have been transferred to 300 µm sieve & to remove any precipitated salt
5. Allow sieve with collected particulate to air dry, wrapping in aluminum foil for containment

E. Residue Analysis
    1. Conduct visual inspection by naked eye & dissecting microscope/stereoscope
    2. Use tweezers to separate collected sample material based on morphology (Figure 8)
    3. Weigh all collected samples

F. Waste Disposal
    1. All solutions disposed of as inorganic waste

5 Data

5.1 Qualitative Analysis

Qualitative analysis of the collected sample focused on identifying the morphologies of microplastics recovered, specifically their physical shape. While some samples yielded a variety of fibres, films, and fragments, others yielded a single plastic form resulting in difficulty discerning any potential consistency amongst collected samples (Figure 9). As such it was indicated that microplastic morphology was highly varied, randomized, and did not follow a distinct pattern. Visual analysis revealed microplastics in the form fragmented plastic were most abundant, however care must be taken to discern thin strips of fragmented plastic from synthetic fibres of similar shape (Figure 10). Film-type plastic are the most distinguishable of the samples, however least commonly found due to the ease of degradation and resultant varying sizes.

5.2 Quantitative Analysis

Quantitative analysis revealed that fragmented plastics were the most abundant microplastic by mass when weighed with an analytical scale. Fragments were collected at four of five locations, with abundance being greatest in the area below the William R. Bennett bridge. Fibres were collected at all locations, with greatest abundance appearing in the region of the lake south of the Mission Creek outflow. Films were collected at three of five locations, with the area north of the William R. Bennett bridge and the area beneath it yielding the greatest number of films.

5.3 Results

Through visual observation via dissecting microscope, it was found the total amount of microplastics collected represented 43% fragments, 31% fibres, and 26% films (Figure 11). Divided by location, 26% was collected north of the bridge, 40% collected below the bridge, 1% above the Kelowna WWTP outfall, 10% from Mission Creek, and 23% collected in the region south of Mission Creek's outflow (Figure 12). Across all location sites, the most even distribution was apparent north of the bridge, where samples contained 23% fragments, 45% films, and 31% fibres. Conversely, samples containing 100% fibres were found in the location above the Kelowna WWTP outfall (Figure 13).

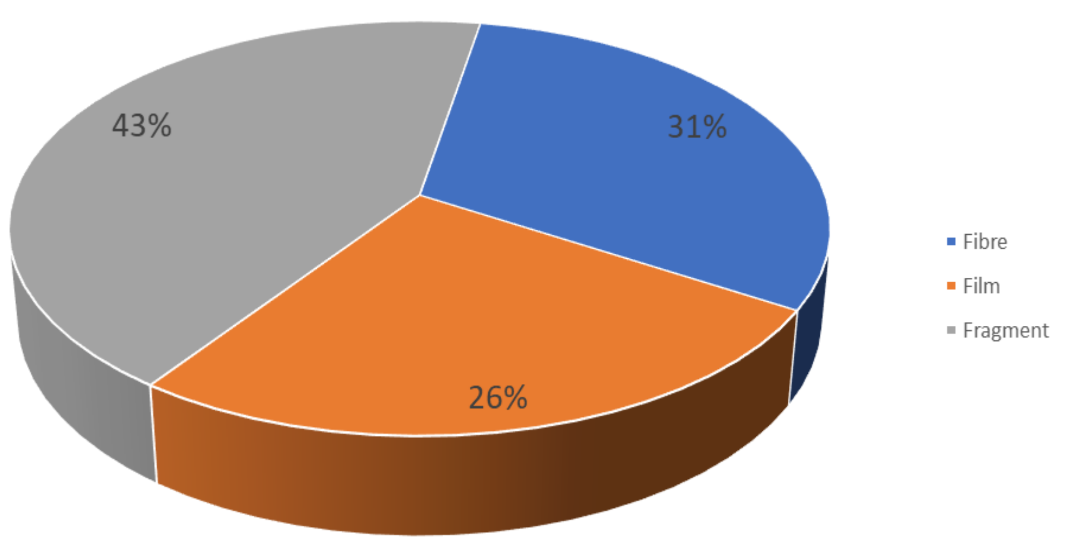

Figure 10: Total microplastics collected, sorted by morphology

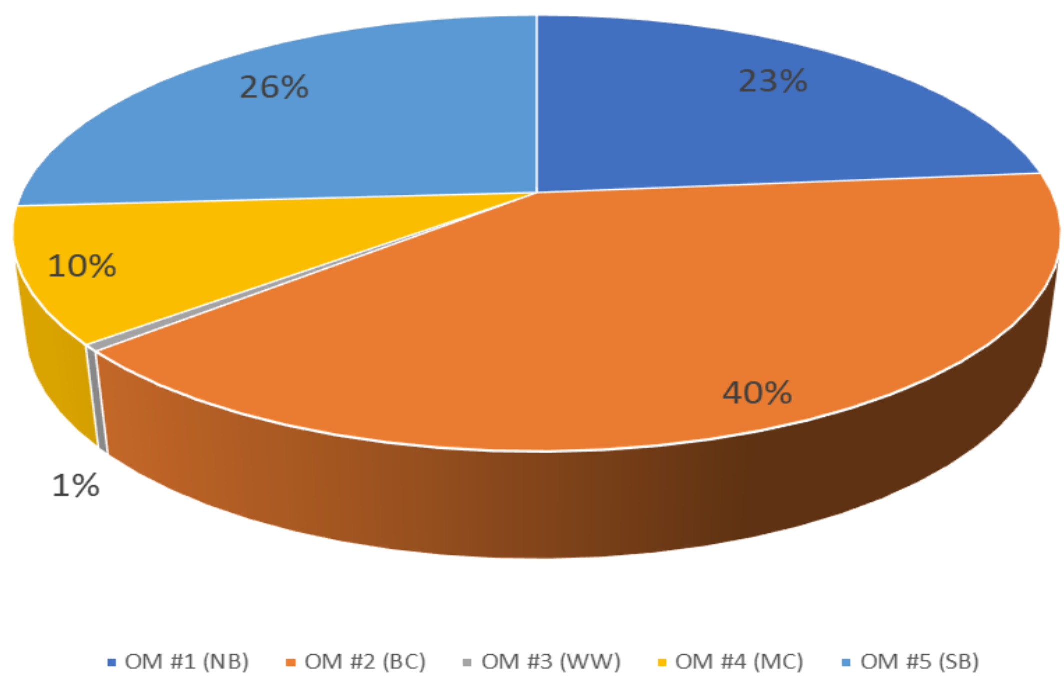

Figure 11: Collected microplastics represented by collection location. (#1 North of Bridge, #2 Below Bridge, #3 Kelowna WWTP Outfall, #4 Mission Creek, #5 South of Bridge).

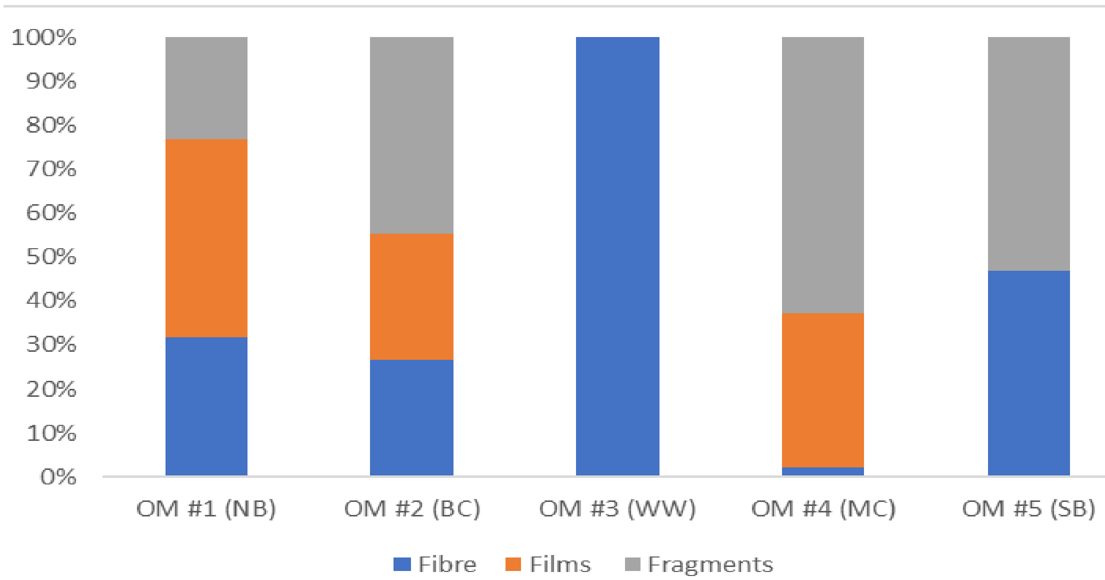

Figure 12: Total microplastics collected, separated by morphology and collection location (L-R, North of bridge, Below bridge, Kelowna WWTP outfall, Mission Creek, South of bridge).

In total, about 2.75 grams of plastic were collected from five sample locations. The greatest concentration of microplastics was collected below the William R. Bennett bridge yielded 1.1009g (Table 2). The least amount collected occurred in the region near the Kelowna WWTP outfall location, 0.012g. Fragments revealed the heaviest mass weighing 1.1925g, trailed by fibres and films with 0.8558g & 0.7098g respectively.

Table 1: Total microplastic mass(g) based on morphology.

Morphology	**Mass (g)**
Fibres	0.8558
Films	0.7098
Fragments	1.1925
Total	**2.7581**

Table 2: Microplastic masses(g) based on morphology, collected from each of the five sample sites.

	OM #1 (N.B.)	**OM #2 (BB)**	**OM #3 (WW)**	**OM #4 (MC)**	**OM #5 (SB)**
Fibres	0.2098	0.2948	0.012	0.0058	0.3334
Films	0.2991	0.3148	0	0.0959	0
Fragments	0.1541	0.4913	0	0.1709	0.3762
Total	**0.633**	**1.1009**	**0.012**	**0.2726**	**0.7096**

Table 3: Location of most abundant microplastic by mass(g)

Morphology	Mass (g)	Most Abundant Location
Fibre	0.3334	South of Mission Creek outflow
Film	0.3148	Below William R. Bennett bridge
Fragment	0.4913	Below William R. Bennett bridge

Table 4: Location of least abundant microplastic morphology by mass(g).

Morphology	Mass (g)	Least Abundant Location
Fibre	0.0058	Mission Creek outflow
Film	0	No representative sample collected at WWTP or south of Mission Creek outflow
Fragment	0.1541	North of William R. Bennett bridge

5.4 Source Considerations

The City of Kelowna was constructed on a historic floodplain, with early settlers navigating many braided stream networks. Many of these waterways were built over and as a result meander through dense industrial and residential areas. Travelling alongside many roads, varying seasonal flow rate can transport collected particulate (including microplastics) downstream to Okanagan Lake.

In the summers of 2017 and 2018, Okanagan Lake flooded to historic levels not seen in 60 years. As a result, residents used many sandbags to create barriers surrounding their properties as a means of flood protection. Insufficient collection and disposal processes post-flood allowed degradation of the synthetic (often polypropylene) bags used for sand, subsequently entering the lake through wind transport and surface runoff.

The William R. Bennett bridge traverses Okanagan Lake at its narrowest point. This bridge holds five traffic lanes and a pair of multi-use pathways for cyclists and pedestrians. It is reasonable to presume that refuse and degraded rubber from tire wear can deposit into the water body by vehicle deflection or wind transport. While not directly a microplastic, it is still a contributing synthetic polymer.
Recreational boaters heavily use the lake through the summer months and lash or moor many pieces of equipment with nylon rope. Similarly, anglers on the lake use various flies and lures of synthetic construction in conjunction with nylon fishing line.

6 Discussion

6.1 Estimated Results

The investigation into whether microplastics existed in Okanagan Lake confirmed its hypothesis: microplastics are present. Not only were plastics visible by examining the stored, pre-filtered sample, many smaller microplastics displaying various morphologies were discovered under microscope. This allowed the team to manually separate the sample by its morphology and obtain a mass to quantify how much microplastic was recovered.

Following the method outlined by Masura et al (2015), it was presumed all organics would be oxidized by the Fenton's Reagent and H_2O_2 reaction. Observations revealed forms of carbon remaining in solution, as well as noticeable colour from tannins and metal oxides present. It was discovered the reaction is enhanced when UV light is applied (USP Tech, 2020). Furthermore, equilibrium is maintained in the hydroxyl radical reaction with an application of hydrochloric acid (HCL). The ideal pH range for reaction effectiveness was found to be maintained at 3.5-4.5, otherwise the metal oxides develop the ability to coagulate and precipitate out of suspension and settle (Azber, 2003). Azber also stated temperatures should not exceed 40°C - 50°C, significantly reducing the risk of the exothermal reaction reaching a boiling point (2015). In density separation, it was observed the aluminum foil covering was degrading over the settling period. Presumed due to interactions with the high H_2O_2 solution, watch glasses were uses as an adequate cover for funnels, however this reduced the volume of solution able to be held in the funnel.

6.2 Impact Statements

Microplastics pose a significant environmental risk when introduced to freshwater ecosystems. Canada holds 20% of the world's freshwater in more than 563 large lakes - the third largest renewable freshwater supply in the world (Fraser Institute, 2018). Plastic has been proven to release chemicals during degradation and absorb other pollutants while bioaccumulating in aquatic life (Fraser Institute, 2018). The objective of confirming if microplastics are present in Okanagan Lake has been completed. This investigation has literally and figuratively only skimmed the surface of quantifying how much microplastic is in the lake. Analysis of different stratified layers throughout the water column will reveal varying densities which support microplastics in suspension (Boehrer & Shultze, 2008). Further investigation into sediment layers of the lakebed will also reveal more dense pieces of microplastic that have fallen out of suspension and settled into the substrate (Yang et al., 2020). Okanagan Lake flows into the Okanagan River, subsequently the Columbia River, and terminates at the Pacific Ocean. There are numerous urban centers that are not only contributing microplastics, but, including all the wildlife within the water bodies – are consuming and ingesting this problem. It is conceivable this bioaccumulation will continue and be recognizable at increasing levels of the food chain.

7 Conclusion

Through thorough investigation it can be confirmed that microplastics are present in Okanagan Lake. Very clearly, these microplastics can be categorized into morphologies of fibres, films, and fragments. It must be restated that this analysis only examined the surface layer of Okanagan Lake, with the Manta trawler intercepting just the top two inches of the water body. Repeating the theory that 1% of microplastics in a water body float at the surface, consider the remaining 99% - 14% in suspension and 85% into sediment, it is imperative that future analysis is conducted through the water column. Observing concentrations of microplastics in the rest of the pelagic zone and the benthic sediments will provide a vertical cross section of microplastic distribution within Okanagan Lake. Greater range is recommended to include the urban centers of Vernon and Penticton, as studies can follow transit times of plastics travelling in the north to south flow of the lake. Additionally, study of the main tributaries into Okanagan Lake must be observed for any microplastics than can be carried through rural or forested locations. Ultimately, only more sampling will yield greater understand of the presence, effects, and toxicology of microplastics in freshwater environments.

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9 Appendix

9.1 Figures

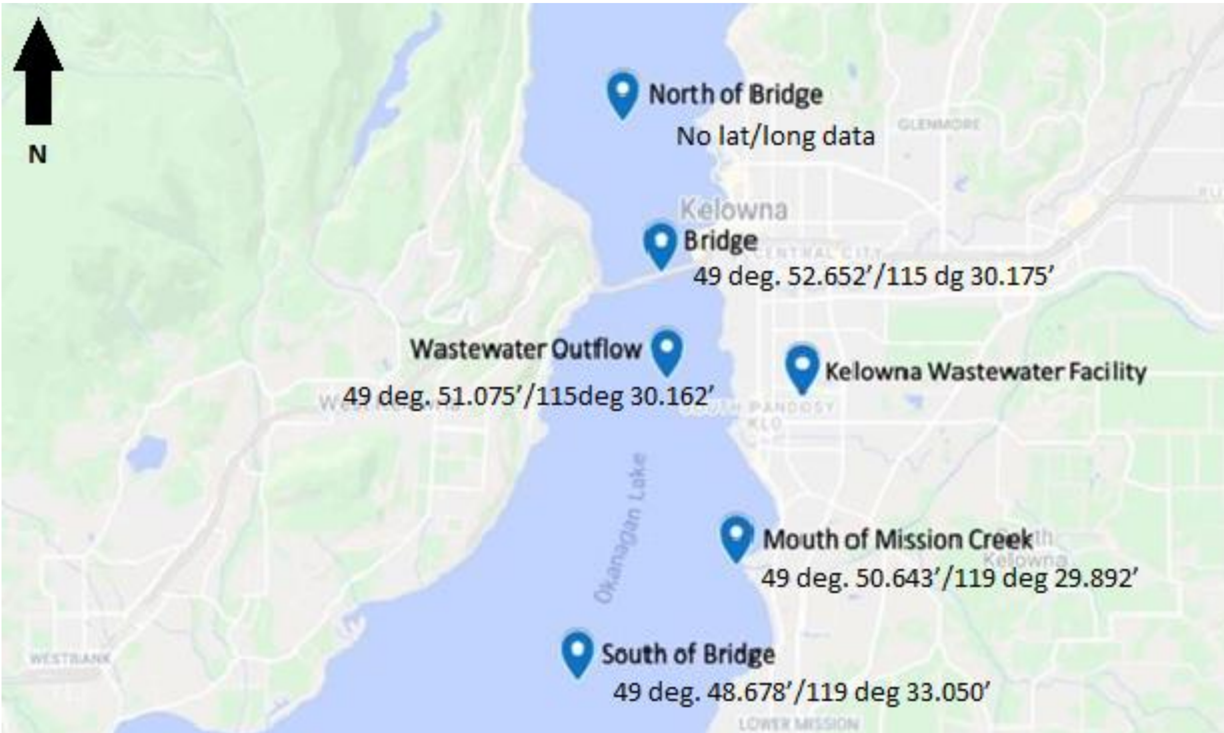


Figure 1: Map of Kelowna highlighting sampling locations, with GPS coordinates referenced where available.

Figure 2: Manta Trawl being towed in water; water can be seen entering the central opening and passing through the netting with a collection point at the end (Photo: Microplastics Okanagan).

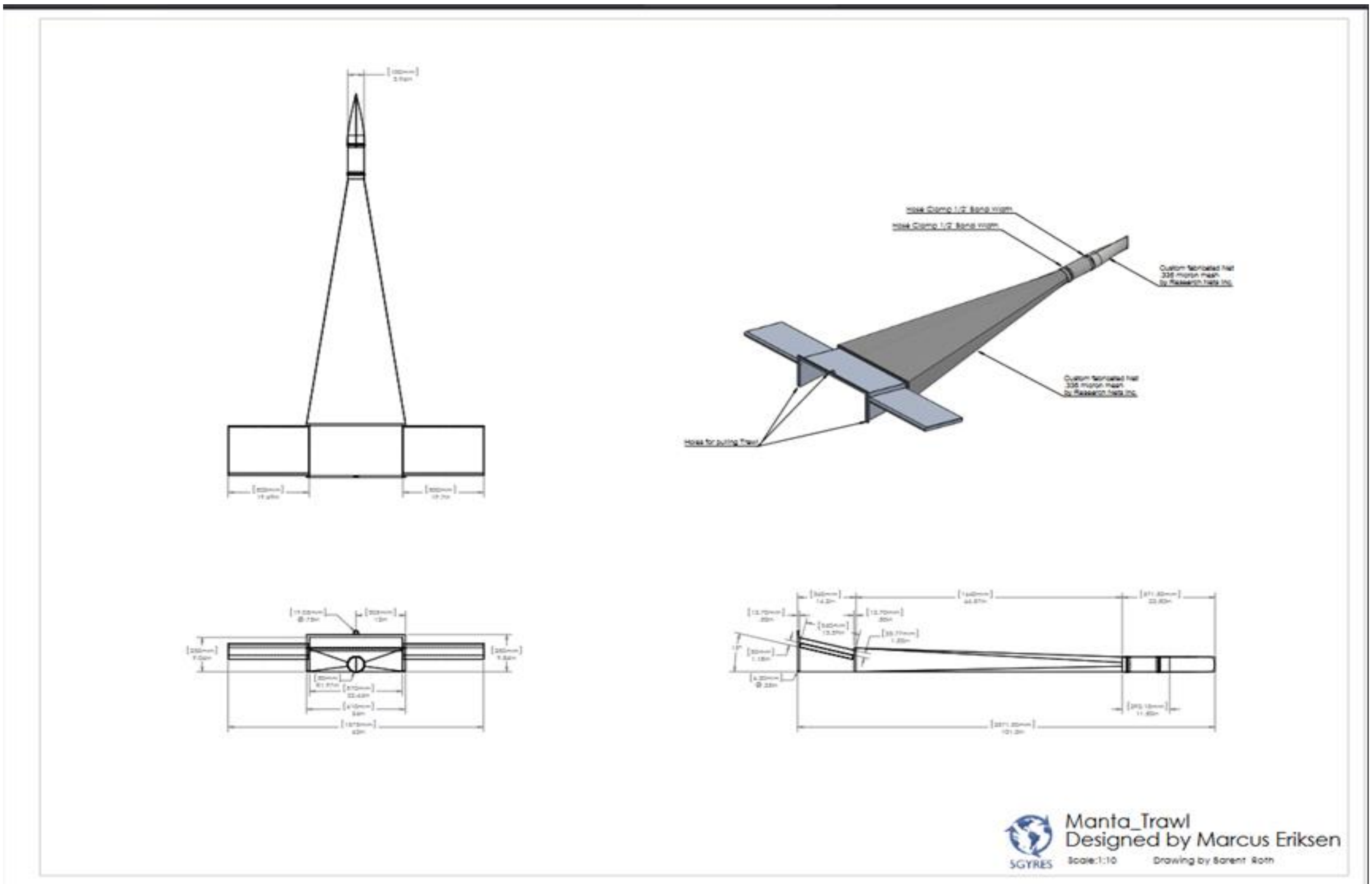


Figure 3: Schematic design plan of Manta Trawl.

Figure 1: Spike sample results post mechanical sifting. Evident is the separation of plastics decreasing in size at each sieve, clockwise 1-5; Rotary Lab Sifter in 6 (Photos: Q. Dartnell).

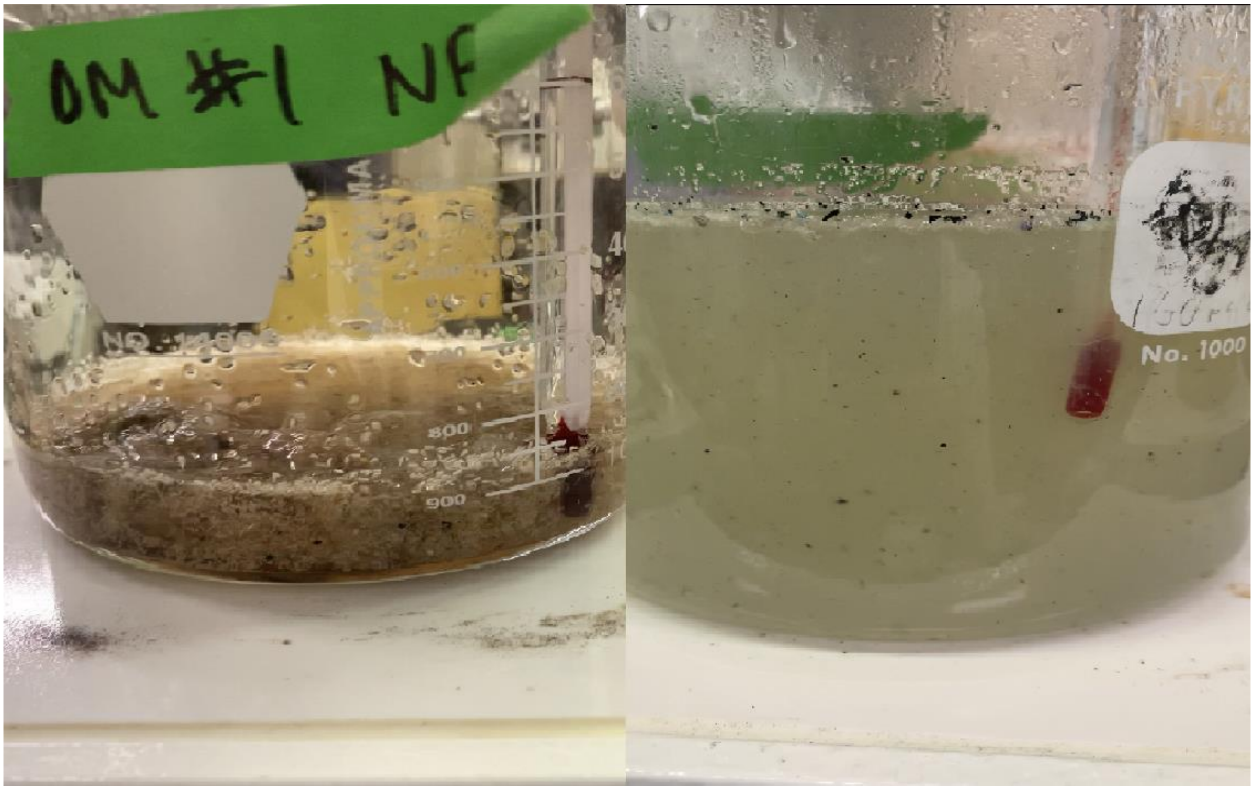


Figure 5: Plankton & organics at beginning of digestion stage (L); Oxidation of organics in solution nearly complete (R) (Photo: J. Sztanko).

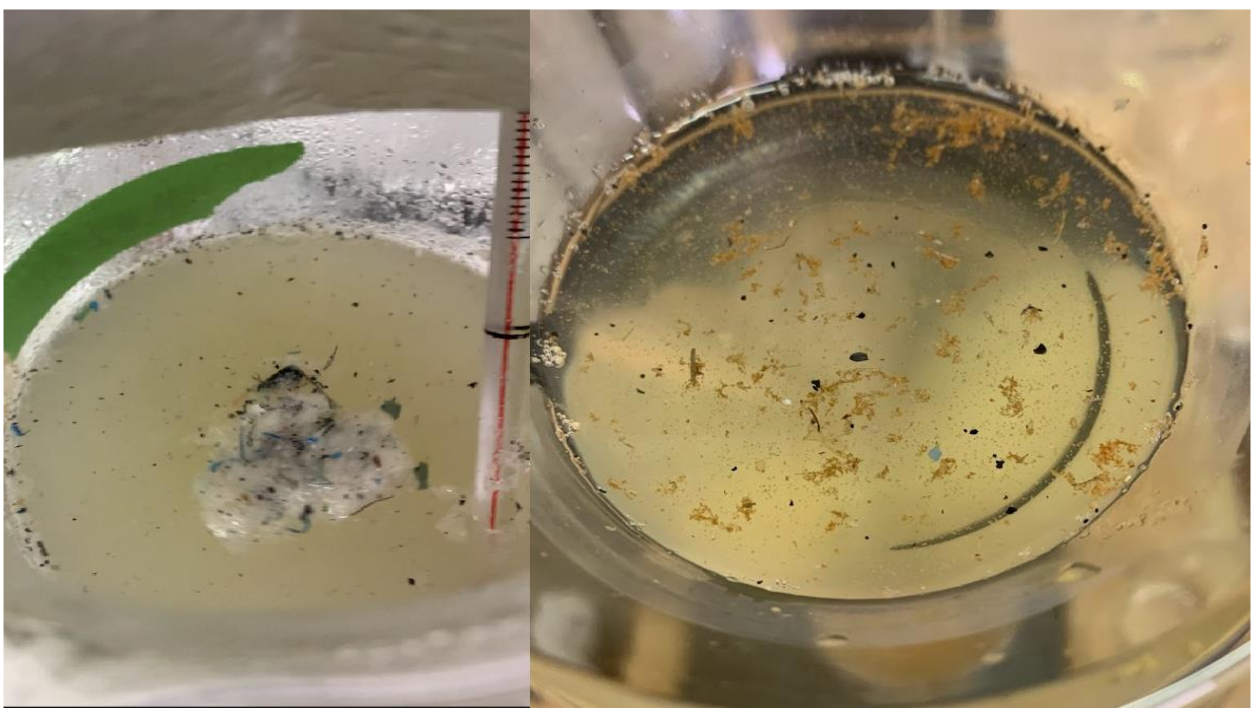


Figure 6: Inorganic material adhered to inorganic tape strip (L); Microplastics & inorganic particulate rising to surface in density separation stage (Photo: J. Sztanko (L), Q. Dartnell (R).

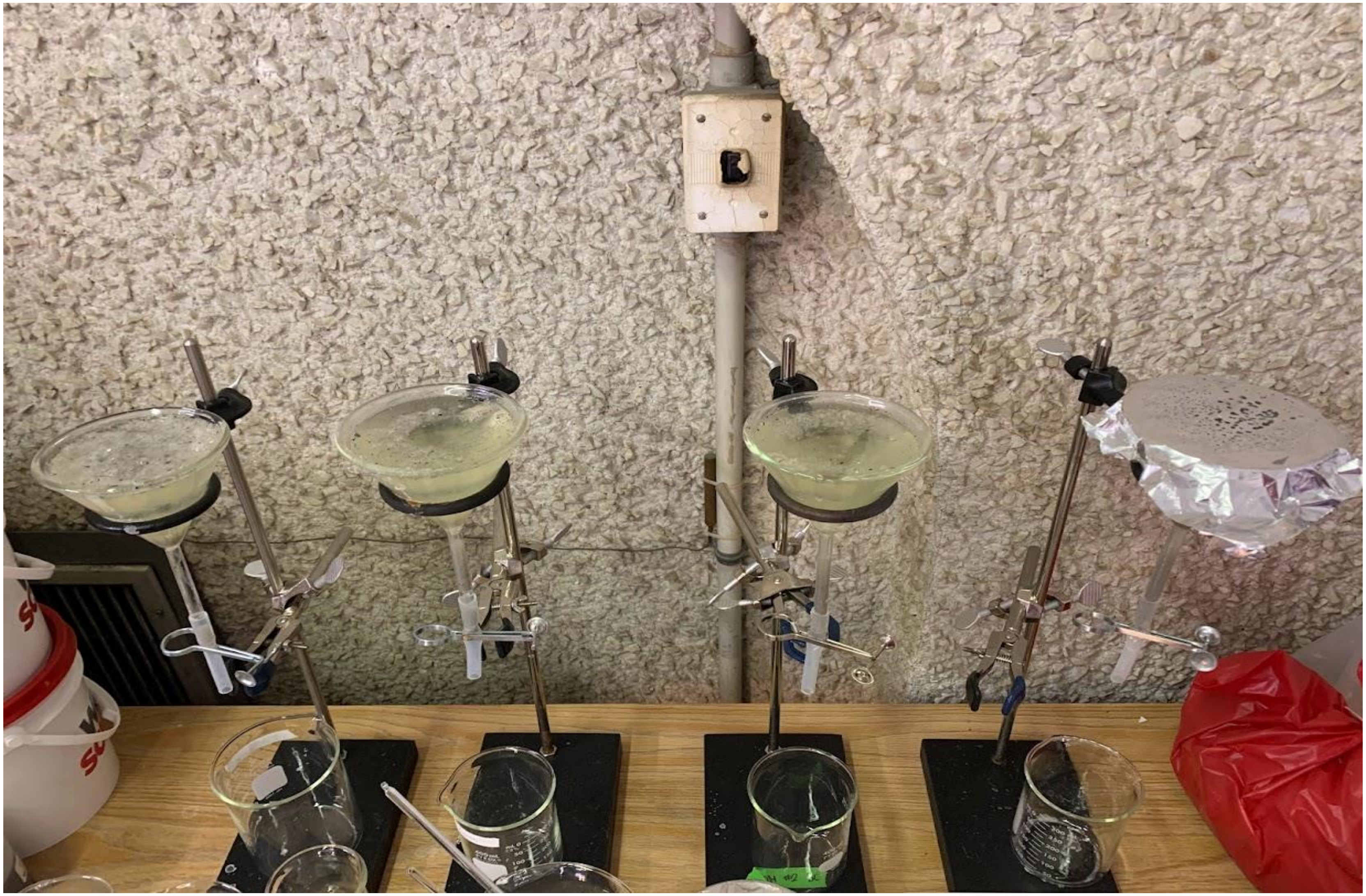


Figure 7: Funnels sitting in ring clamps with clamped hoses attached to stem. Solutions have been poured into funnels for density separation to occur (Photo: Q. Dartnell).

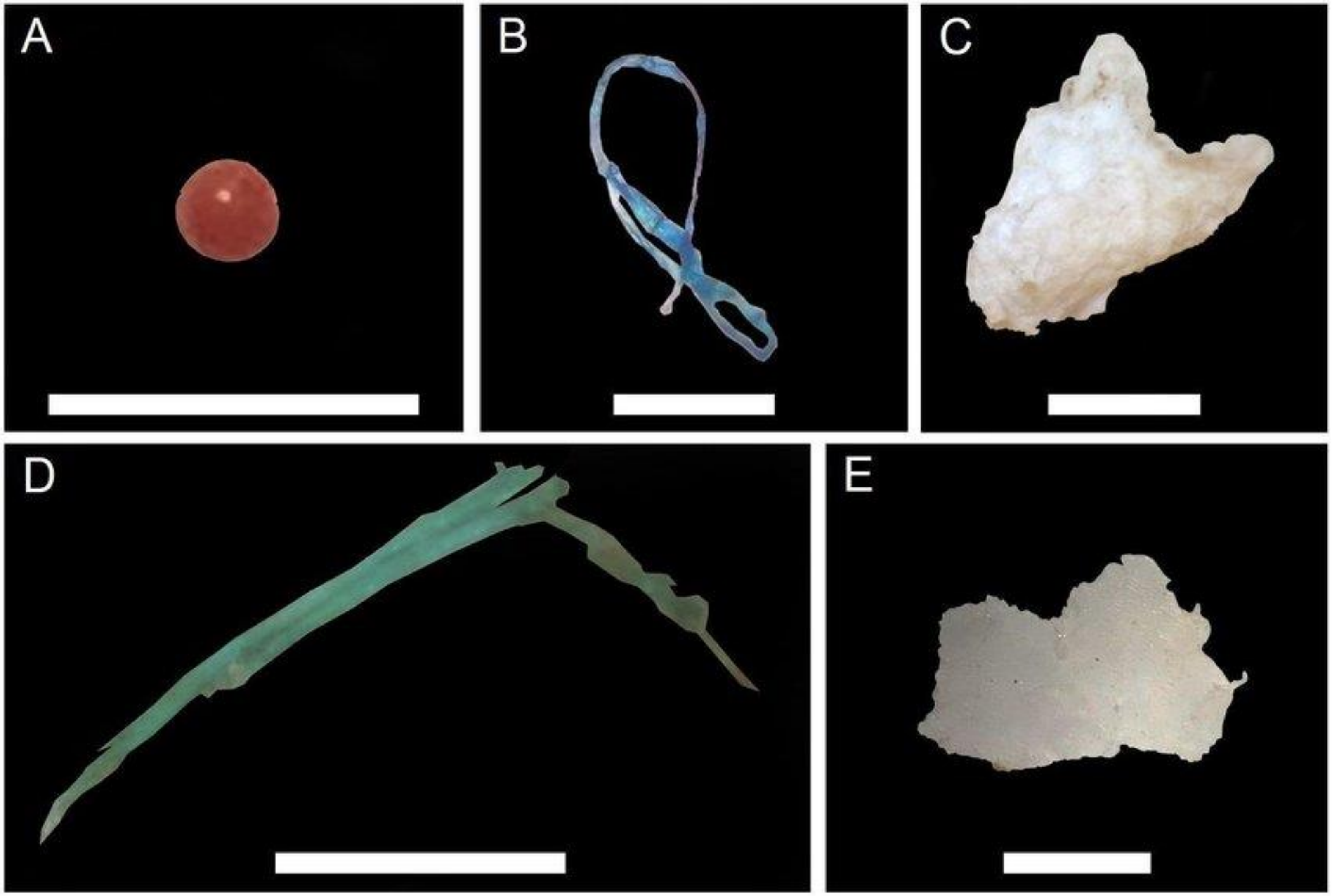


Figure 8: Depictions of microplastics when viewed under microscope, identifying fragments (A), fibres (B, D), and films (C, E) (Photo: De la Torre et al).

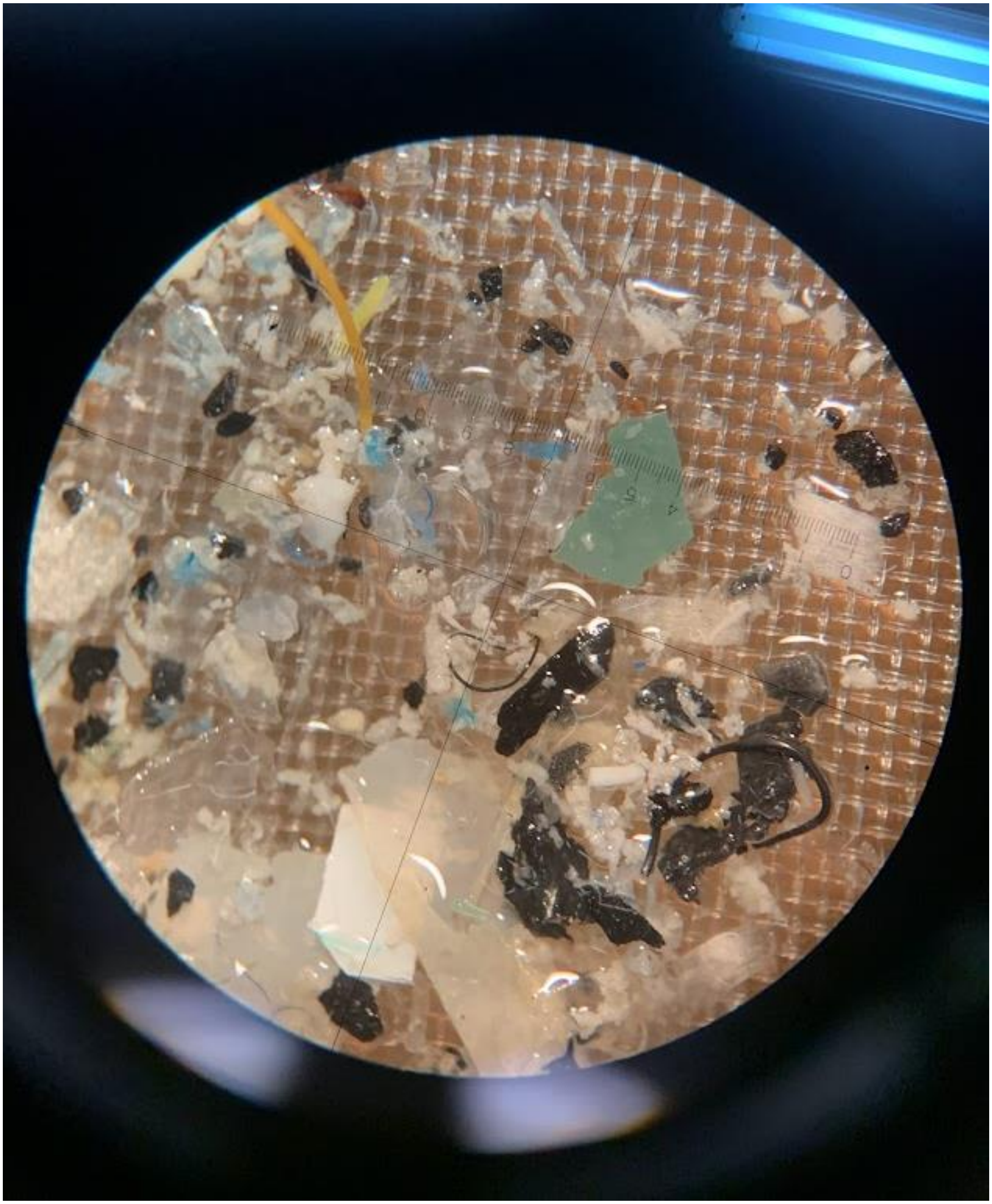
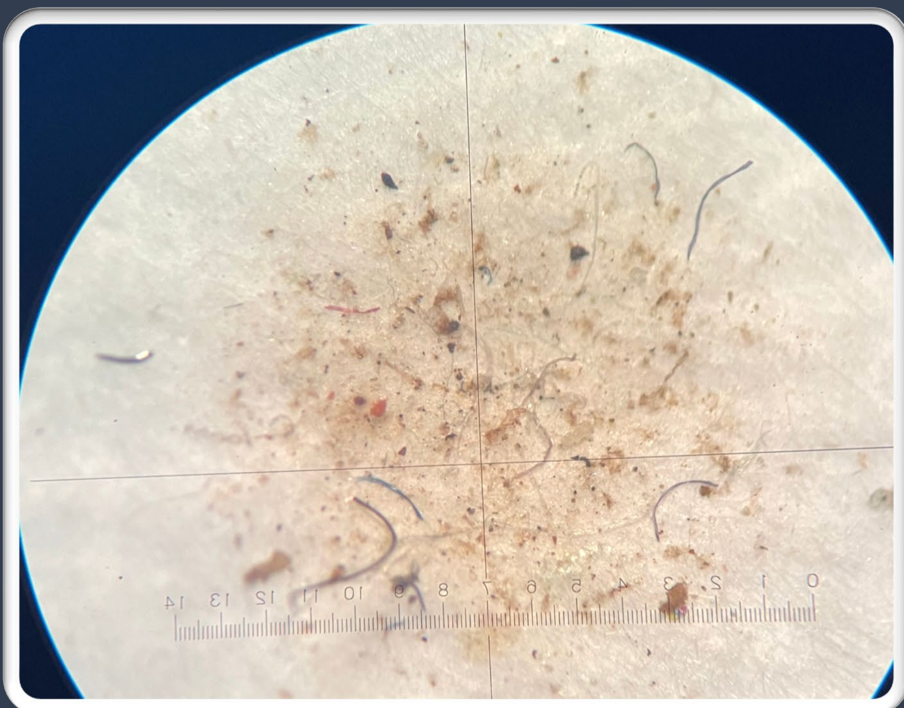


Figure 9: Varying colours and shapes of microplastics post density separation (Photo: J. Sztanko).

Figure 10: Array of microplastics and other inorganic material; fibres, films and fragments all appear in addition to suspected carbon & rubber (Photo: J. Sztanko)



Investigation done to find out if there are microplastics being discharged in the lake Okanagan from Kelowna Wastewater Treatment Plant

Okanagan College WET Capstone Project Report

MICROPLASTICS IN WASTEWATER

Harjit, Jongsun, Sherry, Tejveer

MICROPLASTICS IN WASTEWATER

Table of contents

MICROPLASTICS IN WASTEWATER

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MICROPLASTICS IN WASTEWATER

Introduction:

Microplastics are an alarming issue that has not much known but has huge impact on marine life and so it can be related to wastewater as well, as the wastewater (treated) ends up in water bodies eventually. As there are microplastics associated with waste produced from households, the idea is to analyze how much is being received in the wastewater treatment plant and after all the process, is there any amount of microplastics being released in the lake Okanagan and if there is any analyze to which extent wastewater is contributing to pollute marine life.

Microplastics existed since past 60 years. Since then, approximately 8 billion metric tons of plastics had been produced. From this produced amount, only 9% has been recycled. Most of it ends up in landfills, environment or make their ways to water bodies.

Plastics are aggregating day by day in the oceans at a very concerning rate. The worst example is the Great Pacific Garbage Patch located between California and Hawaii. It is estimated that it is about three times the size of France.

FIGURE 1 : THE GREAT PACIFIC GARBAGE PATCH, RETRIEVED FROM: HTTPS://GLOBALGOODNESS.CA/EN/SAILBOAT-COLLECTS-103-TONS-OF-PLASTIC-IN-THE-PACIFIC/

Like other types of pollutions, plastic pollution is also very common and visible. But the ones that are hard to see and not much has been done to identify and address them are, **Microplastics**. Plastics are non-biodegradable thus they stay in the oceans for so long as they break down into smaller particles (Microplastics) sizes less than 5mm. There are hundreds of millions of tons microplastics waste that sits in the oceans.

MICROPLASTICS IN WASTEWATER

There has not been done so much yet to how to tackle this problem and what are their adverse effects on the marine life and overall environment. But worldwide, research is ongoing to find how to deal with this problem. (The University of Nottingham, 2018)

"There is now **5.25 trillion macro and micro pieces** of plastic in our ocean & 46,000 pieces in every square mile of ocean, weighing up to 269,000 tons. Every day around 8 million pieces of plastic makes their way into our oceans." (&64;CondorFerries)

This report will mainly focus on the microplastic pollution contribution from The City of Kelowna Wastewater Treatment Plant towards Okanagan Lake.
Wastewater treatment plant emanating has been distinguished as a likely wellspring of microplastics. Microplastics have as of late been identified in wastewater gushing in Western Europe, Russia and the USA. As there are just a modest bunch of concentrates on microplastics in wastewater, it is hard to precisely decide the commitment of wastewater gushing as a wellspring of microplastics. Notwithstanding, even the modest quantities of microplastics identified in wastewater emanating might be a noteworthy source given the huge volumes of wastewater treatment gushing released to the oceanic climate every year. Further, there is solid proof that microplastics can communicate with wastewater-related foreign substances, which can possibly ship synthetics to amphibian life forms after exposure to microplastics. (Ziajahromi et al., 2016)

PROJECT OVERVIEW

SCOPE: The purpose of this project is to investigate Kelowna wastewater treatment plant if it is contributing towards microplastics in oceans by releasing effluent in Lake Okanagan.

BUDGET: Funding was provided by Okanagan college. All the equipment required, and chemicals required were provide by Chemistry laboratory and Biology laboratory.

EXPECTED BENEFITS: This project will help the FRESHWATER LIFE NGO to go further with their initiative to provide marine life a save environment that is free of microplastics to some extent if City of Kelowna is a contributing factor of microplastics in Lake Okanagan.

CONSTRAINTS/RISKS:

- No practical method available for detecting microplastics in wastewater
- The size and number of microplastic particles present are not at a detectable level.
- Limited amount of time could lead to failure if the developed procedure does not meet the project requirements.

MICROPLASTICS IN WASTEWATER

MILESTONE SCHEDULE

Project Start -September 9,2021

Procedure Start- October 7 ,2021

Project Report submission- November 1 ,2021

Presentation Delivery – December 3 ,2021

METHOD:

SAMPLE COLLECTION:

Samples were collected for influent and effluent both to get a better idea of what is the wastewater treatment plant receiving and what is being discharged into the Lake Okanagan.

For influent, samples were collected after bar screening and before grit removal. To get a better idea of what comes into the treatment plant three samples were collected at different times of the day 7:30 AM, 10:00 AM and 1:00 PM since activities and water use differs from time to time. The volume collected for samples was 3 liters, 1 liter for each time slot. Considering what's coming into the wastewater treatment plant, the influent sample will have a greater number of plastics that might be visible and microplastics too. For that fact, only one liter of sample was taken at three different times, collectively 3 liters of influent sample.

FIGURE 2: INFLUENT SAMPLES COLLECTED IN 1 LITER BOTTLES AT DIFFERENT TIMES AS LABELLED (LOCATION OF SAMPLE COLLECTION: AFTER BAR SCREENING AND BEFORE GRIT REMOVAL)

For effluent, the sample collection was done after the treated water passes through series of 10-micron disk filters and prior to the final UV disinfection step.

FIGURE 3: EFFLUENT SAMPLES TAKEN IN 10 LITER BUCKETS AT THREE DIFFERENT TIME SLOTS

The effluent was collected in 3 buckets of 10L each. As hypothesis, it was assumed that the effluent will have less microplastics present if any, so to capture microplastics in the effluent, large volume was taken.

Procedure:

To detect microplastics in wastewater treatment plant, the procedure developed by NOAA (National Oceanic and Atmospheric Administration) Marine Debris Program was used with some changes according to samples. Since for wastewater analysis, there was no method present, ideas for the procedure were taken from various previous projects done and majority from The NOAA document. [noaa_microplastics_methods_manual.pdf]

Apparatus and Materials

- Stainless steel sieves, ranging from 4000 microns to 63 microns.
- Squirt bottle containing distilled water
- 500-mL glass beaker
- Analytical balance (precise to 0.1 mg)
- Metal spatula
- Drying oven (90^{o}C)
- Iron (Fe (II)) solution (0.05 M)

Prepared by adding 7.5 g of FeSO4°7H20 (= 278.02 g/mol) to 500 mL of water and 3 mL of concentrated sulfuric acid

- 30% Hydrogen peroxide
- Stir bar
- Laboratory hot plate
- Watch glass
- Sodium chloride
- Standard Metal Forceps
- Density separator, which is assembled using the following method:

A glass funnel is fitted with a segment of latex tubing on the bottom of the stem and a pinch clamp is attached to control liquid flow from the funnel.

- Retort stand
- O-ring
- Spring clamp
- Aluminum foil
- Dissecting microscope (40X magnification) (Arthur, Baker, Foster,Masura,, 2015)

Influent and effluent were treated with different procedures.

Influent: The procedure for influent analysis was processed with pouring the sample through series of stainless-steel mesh sieves. The pore size of the sieves is 4000microns<2000microns<500microns<250microns<125microns<63microns.

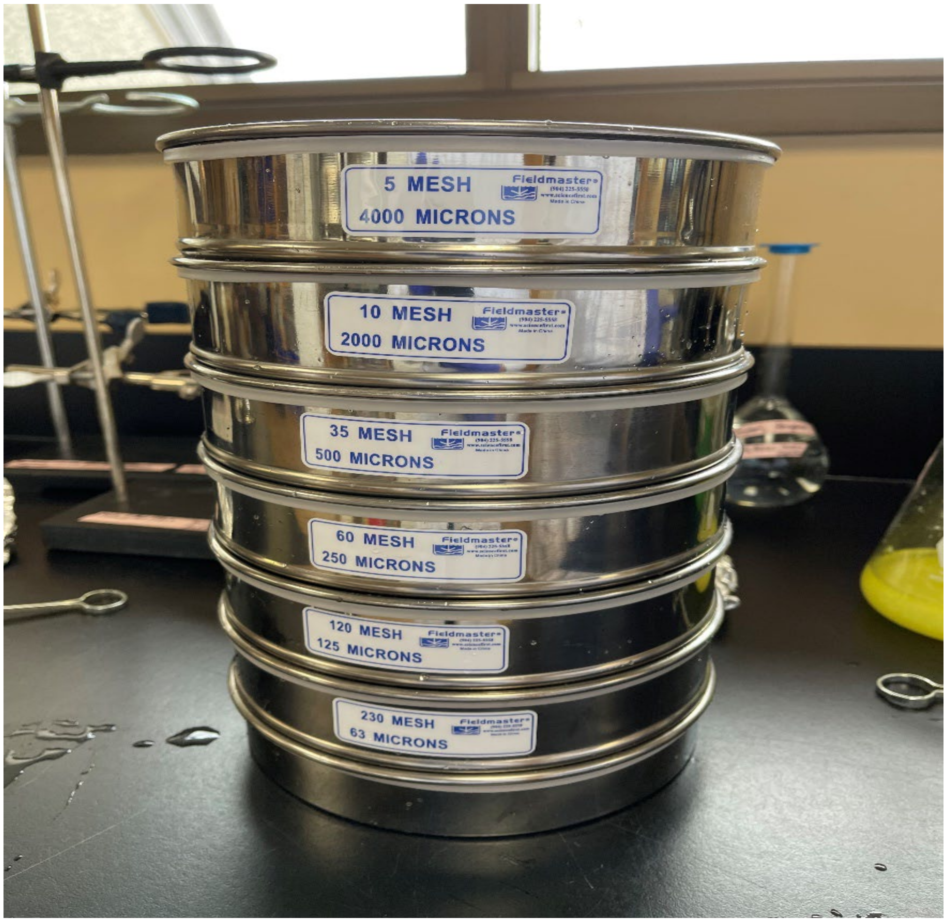

FIGURE 4: STAINLESS STEEL MESH SEIVES USED IN THE PROCEDURE

The material collected on the sieves was scraped off and transferred into beakers (figure 5). Microplastics are ranging less then 5 mm and the smallest pore size in the sieves was 63 microns (Figure 4). The filtrate was discarded following proper laboratory procedures.

FIGURE 5: MATERIAL COLLECTED FROM THE SIEVES AND STORED IN BEAKER

The influent sample have so many unnecessary substances other than microplastics that are focus of this report. To get rid of these, mostly organics and microorganisms, WPO (Wet Peroxide Oxidation) was followed. For WPO, 20mL of 0.05M Fe (II) solution was added to the material collected from the sieves into beaker. After addition of that, 20mLof hydrogen peroxide was added. The solution was mixed on hot plate for about 30 minutes monitoring the temperature of the solution and maintaining it below 75^{o}C carefully as the reaction itself is exothermic. If the solution starts to boil or exceed the temperature distilled water can be added to the beaker.

If natural organic material is visible, add another 20 mL of 30% hydrogen peroxide. This process was repeated until no natural organic matter was left. Add ~6 g of salt (NaCl) per 20 mL of sample to increase the density of the aqueous solution (~5 M NaCl). Mixture was heated until it dissolved. This mixture was transferred into density separation apparatus and covered loosely with aluminum foil and allowed to settle down overnight.

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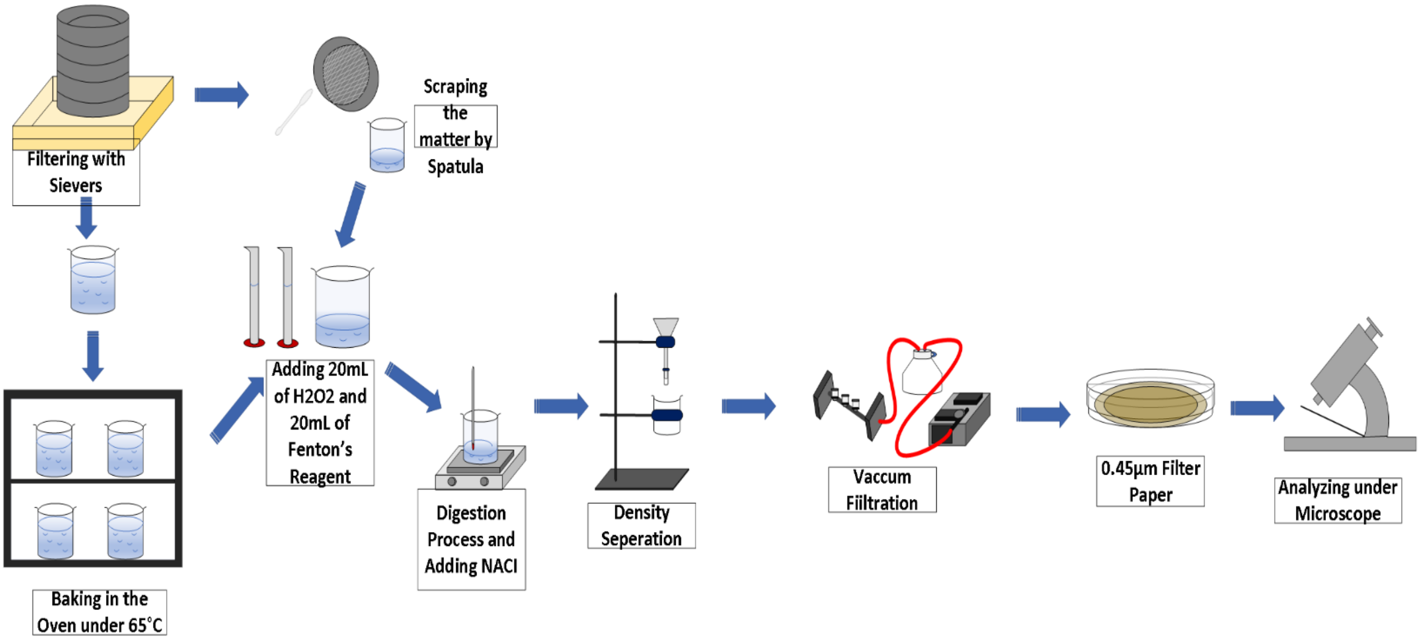

FIGURE 6: PICTURE REPERSENTING HOW THE PROCEDURE WAS FOLLOWED

FIGURE 7: DENSITY SEPERATION SETUP

The settled solids were released and discarded, and the remaining was filtered using vacuum filtration apparatus. The filter used for influent samples was Sartorius Gridded Sterile Cellulose Nitrate Membrane Filters with pore size 0.45µm.

FIGURE 8: VACUUM FILTRATION SETUP

EFFLUENT: Effluent sample was not loaded with unwanted stuff as influent, as it went through 10-micron filters. The effluent samples were directly processed for vacuum filtration step. The filters used for effluent were glass microfiber filters with pore size 1.5 microns. Because effluent samples were large in volume, instead of using smaller pore size and small diameter filters used for influent samples, the glass microfiber filters were used due to their large surface.

ANALYSIS

For analysis of Effluent and Influent, different pathways were followed.

The effluent samples were undigested and 1.5microns filter paper were used while for influent the sample was filtered through sieves ranges from 4000micrometer to 63 micrometers.

After done with all filtration procedure, all the filter papers for both effluent and influent were observed under Dissecting Microscope. Since we were relying on three rules of Hidalgo-Ruz theory, there might be some particles that were misread or left due to lack of some appropriate technology to identify the microplastic particles quantity wise.

FIGURE 9: DISSECTING MICROSCOPE USED TO COUNT MICROPLASTICS AT 40 X MAGNIFICATION.

To find the number of plastics in the sample (both effluent and influent), first dissecting microscope was used at 40x magnification. To count the number of Microplastics (MPs), the glass fiber filter(1.5microns) used for effluent was divided into quarters.

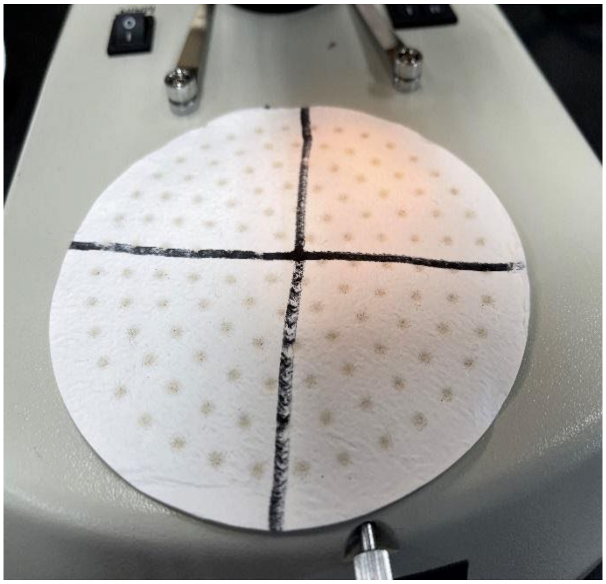
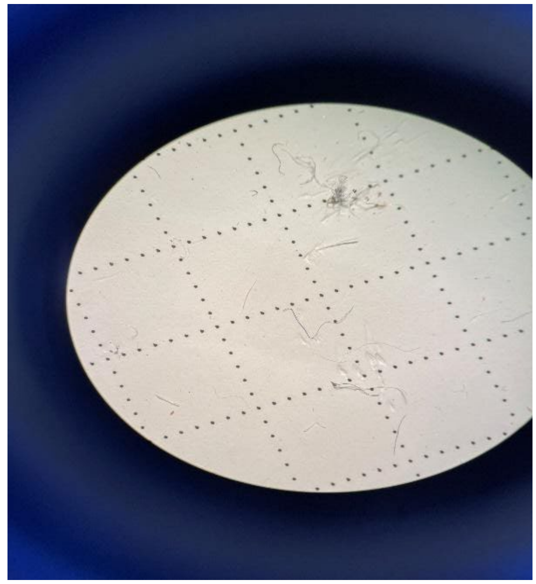

FIGURE 9 LEFT PICTURE SHOWS THE 1.5MICRONS GLASS MICROFIBER FILTER USED TO COUNT MP IN EFFLUENT. RIGHT PICTURE SHOWS THE 0.45 MICRONS SARTORIUS GRIDDED STERILE CELLULOSE NITRATE MEMBRANE FILTER USED FOR INFLUENT.

Microplastics were identified as DEFINITE AND POSSIBLE based on Hidalgo-Ruz Rules:

- **Rule 1: No Cellular or Organic Structures Visible**

FIGURE 10: MICROPLASTIC PARTICLE OBSERVED UNDER DISSECTING MICROSCOPE

FIGURE 11 : MICROPLASTIC PARTICLE OBSERVED UNDER COMPOUND MICROSCOPE

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- **Rule 2: Fibers Should be Equally Thick Throughout Their Entire Length**

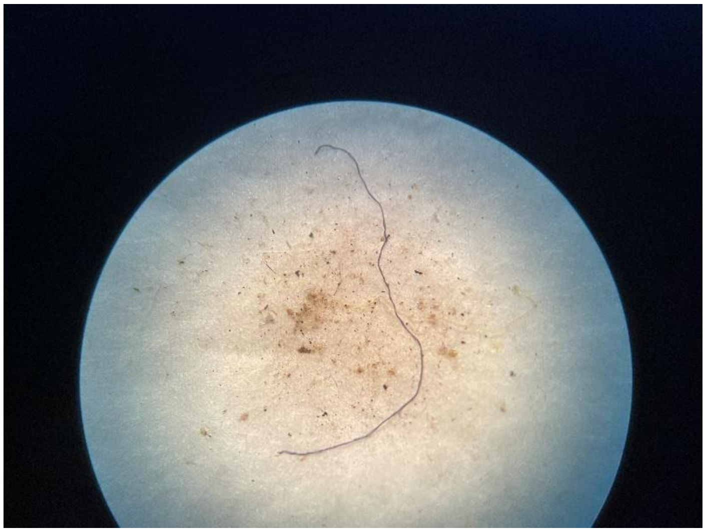

FIGURE 12: A FIBRE UNDER DISSECTING MICROSCOPE FOLLOWING RULE 2

- **Rule 3: Particles should exhibit homogeneous color throughout**

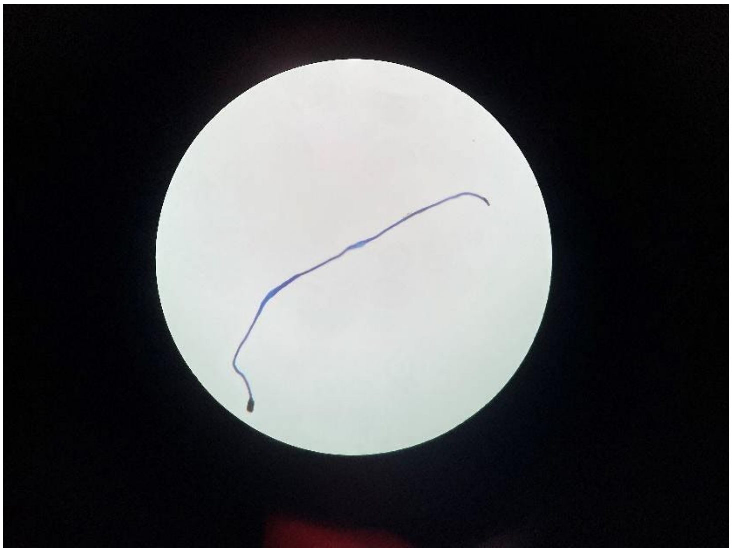

FIGURE 13: A MICROFIBRE FOLLOWING RULE 3

Hot needle test

Hot Needle test is used to differentiate the plastic piece and organic matter. In this test, a hot needle is used on possible plastic piece. Plastic will melt and curl, but biological matter will not. Hot needle test is not suitable to conduct when pieces are in contiguity but perfectly work with scattered fragments. VERY HOT NEEDLE is used to plastic piece, and the changes can be seen under microscope. Compound microscope was used for suspicious pieces if all the three rules were not followed.

FIGURE 14 LEFT PICTURE SHOWS RED MICROFIBER BEFORE HOT NEEDLE TEST WHILE RIGHT PICTURE SHOWS AFTER THE HOT NEEDLE TEST.

MICROPLASTICS IN WASTEWATER

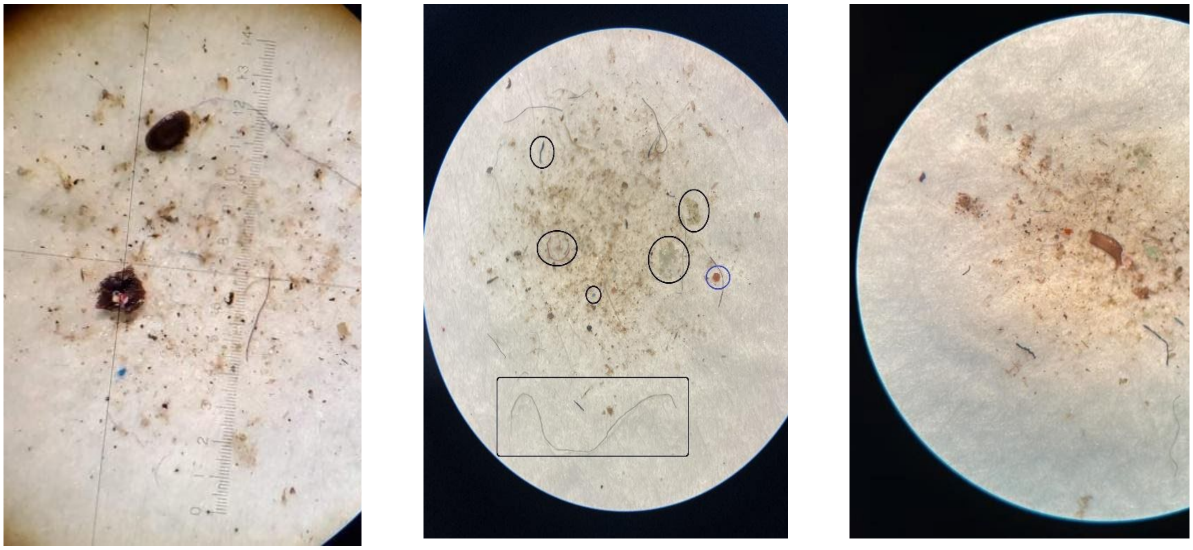

FIGURE 15: DIFFERENT MICROPLASTIC PARTICLES AND NON MICROPLASTIC PARTICLES FOUND FROM BOTH FLOWS

DATA

To get results after following procedure and analysis, dissecting microscopes were used to count Microplastics on filters. FOR INFLUENT samples, Nitrocellulose filter (0.45 microns) used after digestion while for EFFLUENT samples (undigested) Glass fiber filters(1.5microns) were used.

EFFLUENT	TIME	DEFINITE	POSSIBLE
	8 30 AM	209	135
	10 30 AM	252	193
	1 30PM	372	271
INFLUENT	7 30 AM	69	187
	10 00 AM	60	121

Graphical representation of data collected above:

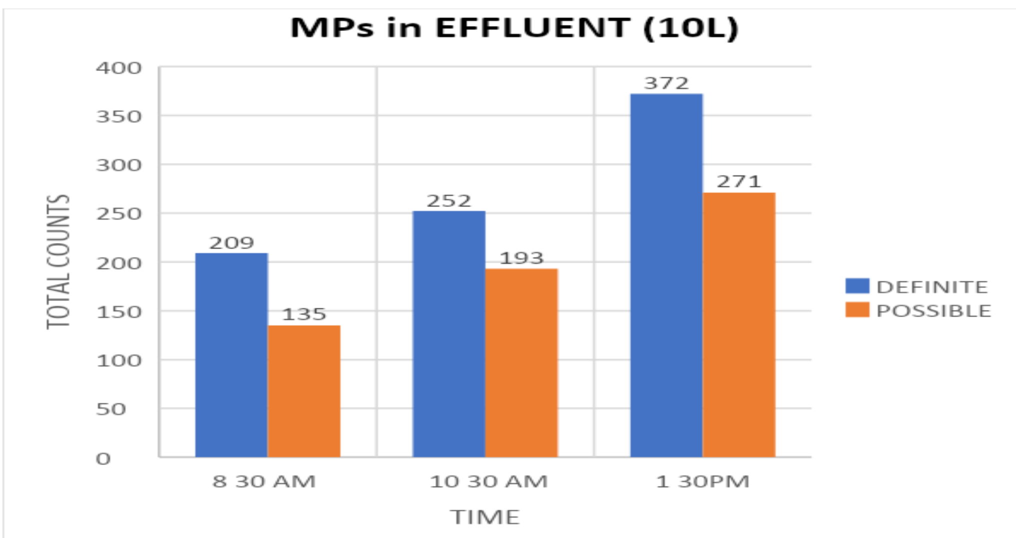

FIGURE 14: MICROPLASTIC COUNT FROM EFFLUENT IN 10LITER SAMPLES

MICROPLASTICS IN WASTEWATER

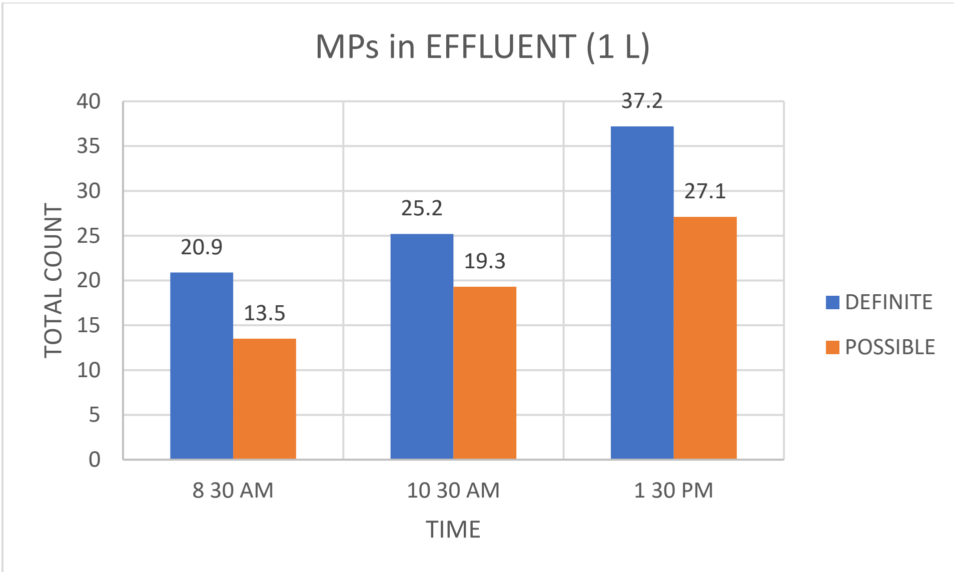

FIGURE 15: MICROPLASTIC COUNT FROM EFFLUET SAMPLE AS IN 1LITER SAMPLE

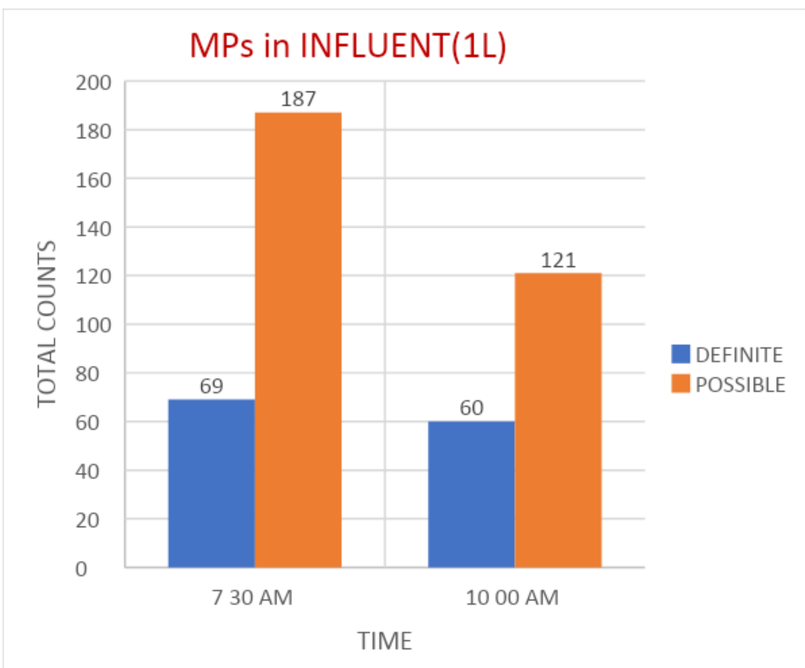

FIGURE 16: MICROPLASTIC COUNT FROM INFLUENT IN 1LITRE SAMPLES

DISCUSSION

Based on our data collected, on average the total count of Microplastics in Influent is 2.5 times more than Effluent.

MICROPLASTICS IN WASTEWATER

Since we were relying on three rules of Hidalgo-Ruz theory, there might be some particles that were misread or left due to the lack of some appropriate technology to identify the microplastic particles quantity wise. Particles observed on filters were divided into two categories: Definite microplastics and Possible microplastics.

For example, effluent sample collected at 8:30am from figure 18: definite microplastics were counted 209 and the possible ones were 135 on glass microfiber filter with diameter of 110mm in 10L sample.

For comparison purposes, comparing influent and effluent for time slots 10am and 10:30am respectively in 1Liter. In the influent, there were definite microplastics count was 60 and 121 possible and effluent was counted for 25 definite and 19 possible. it can be concluded that the quantity of microplastic particles entering the wastewater treatment plant is more than the number of microplastics that are being released in the Okanagan Lake.

On analysis, based on physical appearance most of the particles were microfibers. Also, some plastic films, fragments and some particles that looks like microbeads were observed.

The most seen colors of the particles were red, blue, black and clear. Some particles with yellow, purple, green and pink color were also observed.

There might have been some contamination while processing samples that might have affected our data results. For sample collection, plastic bottles and buckets were used, could be possible that some plastic particles have entered the samples.

The source of contamination could be environment, a study found that the plastic particles can stay in the air for between an hour and 6.5 days. (Baker, 2021)

RESULTS:

The final influent result for microplastic particles is 4.56×10^9 per day (approximately 5 billion)

The final effluent result for microplastic particles is 2.95×10^9 per day (approximately 3 billion) that is being released in the Lake Okanagan.

Even though there is no technology being used in the City of Kelowna Wastewater treatment plant to deal with microplastics, still based on our results, the removal efficiency is 35%.

References

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