THE CANADIAN SCIENCE FAIR JOURNAL

ARTICLE

Pristine Waters: A Pioneering Project in Yukon River Microplastic Research

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Age 14 | Whitehorse, Yukon

Canada-Wide Science Fair 2019 Excellence Award: Junior Gold Medal | Youth Cann Innovate Award | Western University $4,000 Entrance Scholarship

Whitehorse, "The Wilderness City", was established at the head of the Yukon River. It has a reputation of having pristine water and air, some of the best in the world. It is home to plentiful wildlife species and untouched wilderness that attracts visitors from across the globe. Situated at the head of the Yukon River, it is before any agricultural or industrial contamination. There is one form of pollution that has never been researched in Yukon and has become a growing issue worldwide. It is microplastic pollution and it has only come into the spotlight recently. Microplastics are small polymer particles, less than 5mm in size. Plastic is probably one of the most versatile materials we have invented. Plastic has revolutionized everything from travel to health. Plastic never decomposes, it just degrades, and becomes smaller and smaller. "Although mismanaged plastic waste is still the main source of marine plastic pollution globally, this shows for the first time that, in some countries, more plastic may be released from our driving and washing activities than from the mismanagement of our waste." -Inger Andersen, 2017.

INTRODUCTION

Our everyday activities are starting to catch up to us. One study showed that by the year 2050 we will have more plastics in the ocean than fish, and 99% of seabirds will have ingested plastic by then. (Chow, 2017). All of this plastic is degrading from photodegradation and abrasion, causing them to become microplastics. As many as 51 trillion microplastic particles-500 times more than stars in our galaxy, litter our seas, seriously threatening marine wildlife (Chow, 2017). It adds up and it just keeps growing. Microplastics have also been shown to reduce photosynthesis and growth in microalgae, a key producer of oxygen for the world. (Prata, 2017).

Most of these studies are in the oceans, not nearly as much research has been done in rivers. Rivers can be the pathways for microplastics to enter the oceans. Many researchers who study contaminants are concerned about microplastics since other chemicals and toxins attach to them. This makes microplastics a greater harm to the environment. The Yukon River is the 20th longest river in the world, 3rd longest in North America, and home to the longest salmon migration in the world. Microplastics in the river will potentially have a negative impact on the salmon, and on water quality for many communities. Microplastics have also made their way up the food chain to human consumption, and they have many negative health effects (Robertson, 2018). Microplastics have been suggested to persist in the deep lung, causing inflammation after chronic inhalation. (Gasperi et al., 2018). Many dyes and additives can be added to the plastic, which once inhaled can cause reproductive mutagenicity, toxicity, and carcinogenicity. With wildlife and people depending on clean river water, and healthy air to breathe, it is important to be aware of our pollutants before they accumulate in the environment.

DOI: 10.18192/csfj.v2i22019xxxx

QUESTION

Are there microplastics in the Yukon River at Whitehorse, and if so, what are the sources?

HYPOTHESES

Hypothesis 1 was made prior to the original samples, Sites A-D. Hypothesis 2 was made after Sites A-D had been studied, and the new hypotheseses were formed prior to the Source Investigations.

Hypothesis 1: It is expected that no microplastics will be found in river water upstream from Whitehorse because it is the first city on the Yukon River. It is assumed that a growing number of polymer particles will be found after the river has passed stormwater drains and the city. These are the most likely pathways for microplastics to enter the river. It is believed most of the microplastics are from synthetic textiles since other researchers have found those to be the most common pollutant (Boucher and Friot, 2017). Note: At this time, atmospheric deposition was not considered, it was believed that plastics enter the waterways in more direct ways (washing machines, degradation, etc.).

Hypothesis 2: It is believed that the largest pollutant is atmospheric deposition since the most particles were found in the sites with the lowest water velocity, suggesting they allow greater accumulation of deposited particles.

It is expected that no microplastics will be found in the tap water since it is sourced from underground wells. It is also expected to find large traces of microplastics in the snow, since the atmosphere is constantly depositing particles on its surface. It is believed that there would be high quantities of microplastic on all of the atmospheric deposition samples since atmospheric deposition is a large contributor of pollutants worldwide. (Gasperi et al., 2018).

MATERIALS

Household metal strainer, 0.3mm/#50 brass sieve, 15L metal bucket, 20L plastic bucket 5mm/ #3.5 sieve, flow meter, squirt bottle, large sink, all-purpose soap, bleach, 600ml beakers, tin foil, fume hood, potassium hydroxide (solid), cotton lab coat, electronic scale, magnetic stirrer, nitrile gloves, coffee filters (approximately 20 microns/ 0.02mm), basic filtration apparatus (glass funnel and retort stand), petri dishes, scissors, microscope, matches, notebook, needle, double sided tape, cardboard.

PROCEDURE

Sites A-D

First, four sampling locations were decided: Upstream from the city (Site A), after all of the storm sewage drains (Site B), Raw sewage before discharge into the river (Site C), and after the city and storm sewers (Site D).

The sieve size range of these samples is 0.3-5mm as used by most studies as the standard range. (Kataoka et al., 2018).

Collection

Advice from Rhiannon Moore and Nicole Novodvorsky.

- Before each use of the equipment, the triple rinse method was used to ensure the equipment was clean and would not interfere with the results. The triple rinse method is simply rinsing every item three times, to avoid contamination.
- Poured water from a 10L metal pail through a 5mm sieve into a plastic pail.
- After that, poured it into a 0.297mm sieve that was sitting in a metal strainer.
- Repeated the last 3 steps 10 times(100L) and took a picture of the #50 sieve each time.
- Repeated the last step 5 times until I reached 500L (50 buckets).
- After 50 buckets, (500L) a squirt bottle filled with water was used to clean all of the particles on the #50 sieve into a sample jar.
- Measured the water velocity at each of the river locations with a flow meter.The following procedure was used:
- Measured the depth of the water and adjusted the flow meter so it was 60% of the depth down.
- Measured the average water velocity after a 40 second period.

Extraction

Advice from Chelsea M. Rochman.

- Calculated amount of 20% KOH (potassium hydroxide) needed for digestion of organic solids in each sample by multiplying the volume of the sample by 3 times.
- Placed magnetic spinner under a fume hood and placed a beaker of water on top of the magnetic spinner.
- Set magnetic spinner to medium speed, then slowly and carefully added KOH until fully dissolved.
- Slowly poured the designated amount of KOH solution into each beaker remaining under a fume hood.
- Moved them to a dry storage area for 8 days.
- Poured samples through 0.3mm sieve one at a time and use a squirt bottle to contain all remaining particles in one corner.
- Sprayed samples out of the sieve and into a coffee filter set up using a basic filtration apparatus.
- Placed coffee filter into a petri dish and cut away excess paper that was not containing particles.
- Immediately washed sieve, KOH would react with brass.
- The sample from Site C did not get digested after over two weeks, the sample was poured back through a 0.3mm sieve to lose KOH.

OBSERVATIONS

Advice from: www.ccb.se/documents/Postkod2017/Mtg050317/Guide to Microplastic Identification_MERI.pdf.

After the sample was dry:

- Put the sample under a microscope and began scanning for plastic fibres.
- Used a chart to help decipher between plastics and organics.
- If necessary, used a hot inoculation loop or needle to touch the particle.
- Kept a tally of the number of plastics, their colour, and their shape.
- All samples were recounted 3 times.

Source Investigations

SNOW

Advice from Liisa Jantunen.

- Found sampling locations: Snow on the lawn from the driveway (SNOW 1), Snow near the highway (SNOW 2), and fresh snow on the ground for up to 15.5 hours (SNOW 3).
- Filled a metal pail with 10L of hand-packed snow.
- Let snow melt while covered by tin foil.
- Poured water (approximately 6L) through a 0.3mm sieve.
- Rinsed contents from the sieve in beaker and covered in tin foil
- Poured wet sample through a coffee filter.
- Put the coffee filter with the sample in a petri dish and let dry.
- Counted microplastics under a microscope.

TAP

- Three 50L tap water samples were taken (TAP 1–3), and one 500L sample was taken (TAP 4).
- Filled metal pail with 10L of water from bath faucet.
- Poured water into 0.3mm sieve.
- Repeated last steps 5 times for a 50L sample, 50 times for a 500L sample.
- Rinsed the contents of the sieve into a beaker.
- Poured the sample onto a coffee filter, and moved it into a Petri dish.
- Counted microplastics under a microscope.

AD

Advice from Hayley Hung.

Decided on the 4 sampling locations: Inside a laboratory (AD 1), in a household living room (AD 2), In a household basement (AD 3), and in an urban backyard (AD 4).

- Cut 4 large squares of cardboard, large enough for two 60cm² sample collectors.
- Cut 4 small squares of cardboard, 60cm² square inches in size.
- Covered each small square with double-sided tape, leaving the top tape cover on.
- Used double sided tape to stick small square to the corner of the large square.
- Removed tape cover and set on a high shelf.
- Set for a week for AD 1-3.
- Set for 24 hours for AD 4.

RESULTS

Microplastics were found at all of the sampling locations. Based on the average amounts in my river samples, It was estimated that over 600 million microplastics flow past Whitehorse every day in the fall. The majority of polymer particles were filaments. There were also blue-green, globule-shaped particles found at every location. Site B was the only sample that had a majority of globules. The sites with the slowest water velocity carried the greatest amount of particles.

Microplastics were found in all SNOW samples with the greatest amounts found in SNOW 1, old snow that had been on the ground for up to 6 months. SNOW 1 had 9.5 particles per litre of snow. 99% of these particles were microfibres.

TAP samples showed mostly consistent results, other than TAP 2 which spiked by 400% more than the two other 50L samples. I raised the sample volume from 50L to 500L to decrease the relative contribution of contamination from the atmosphere. The larger sample had a consistent amount of microplastics per litre, compared to the others. These samples were only from one faucet. All of these particles were microfibres.

Microplastics were found in all AD samples. AD 2 and 3 were similar in amounts, while AD 1 collected much less and was in a low to no traffic area. The results of AD 4 were comparably higher to the indoor samples, approximately 123% increase to the mean of AD 1-3. All of these particles were microfibres.

DISCUSSION

The abundance of microplastic in Whitehorse is more than was expected. This reveals for the first time, the scale of our local pollution. With microplastics found in the Whitehorse river water, wastewater, tap water, snow, and atmospheric deposits, Whitehorse is not as pristine as its citizens believed. Over 600 million microplastics flow past Whitehorse every day. Microplastic studies are a new topic entering environmental science. Most researchers use manta net trawls to collect surface water microplastics. These are difficult to obtain, therefore sampling with a pail is not as comparable to others. The Source Investigation methods are even more recent. All laboratories that were contacted that are conducting similar research have not completed their studies.

Microplastics were found at all sites, A-D. Since the greatest amounts in Sites A-D were the ones with the slowest water velocity, this leads me to suggest that atmospheric deposition accumulation in the river is the most probable pollutant. It was surprising to find the greatest number before the city, as it was hypothesized that it would be the least polluted. However, there is a large watershed upstream from Site A that could be contributing microplastics deposited from the atmosphere.

62% of the microplastics in Sites A-D were synthetic textile fibres. Although 100% of the particles found in the AD samples were filaments, meaning that only 62% of the polymer particles in the river could have been the result of atmospheric deposition. The plastic fragments found in Sites A-D are most likely the result of the degradation of much larger plastic items in the waterways. Site B was the only site that had a majority of globule particles. This

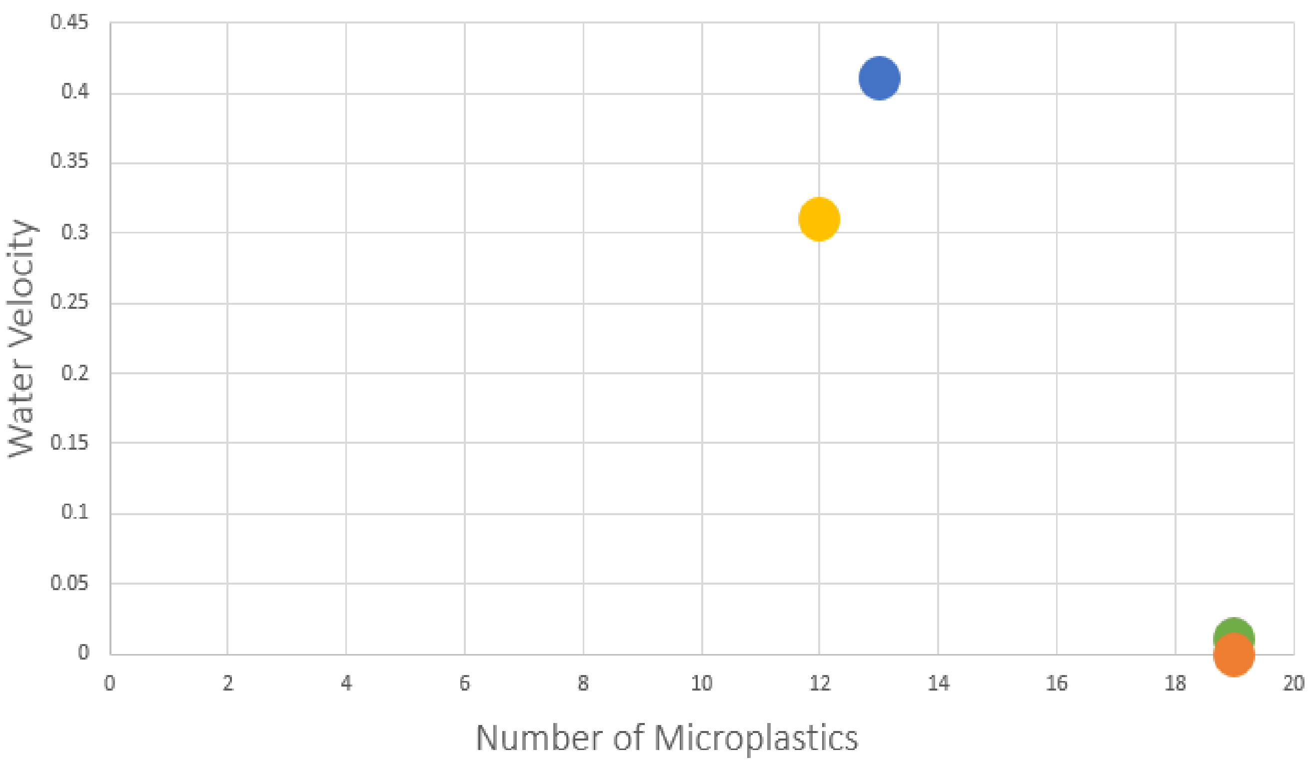

Figure 1. Number of microplastics and water velocity: Sites A-D. Green: Site A, Yellow: Site B, Orange: Site C, Blue: Site D.

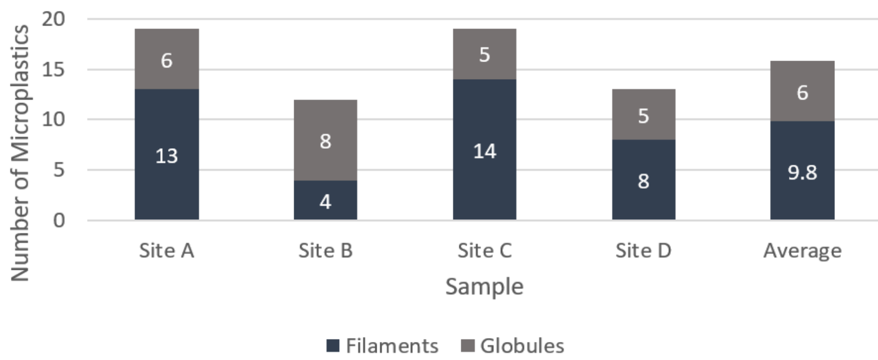

Figure 2. Shape and number of microplastics: Sites A-D

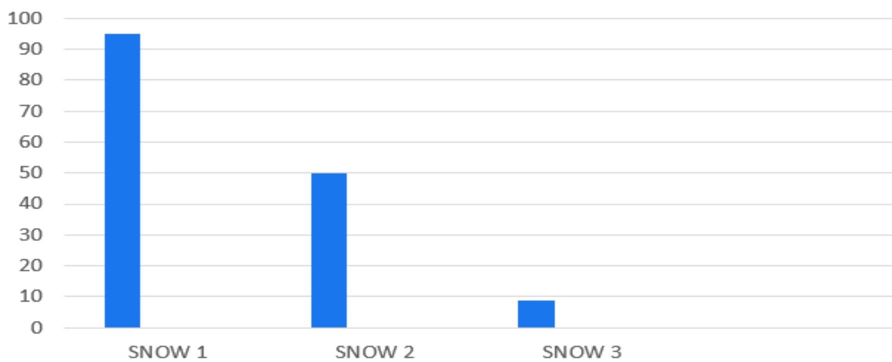

Figure 3. Number of particles - SNOW

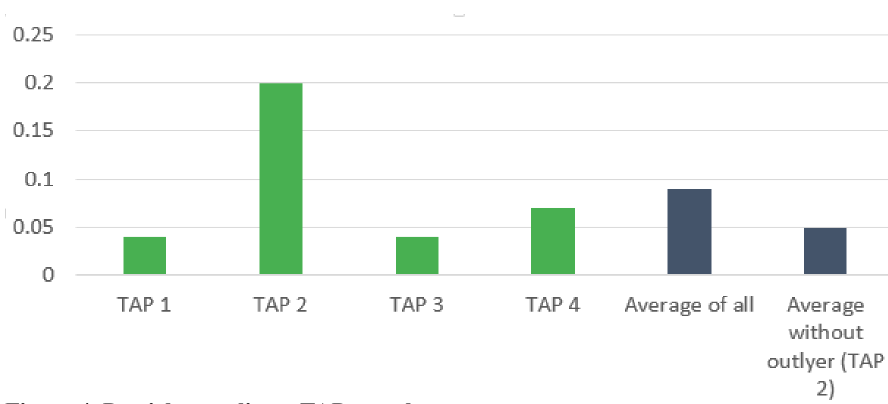

Figure 4. Particles per liter - TAP samples.

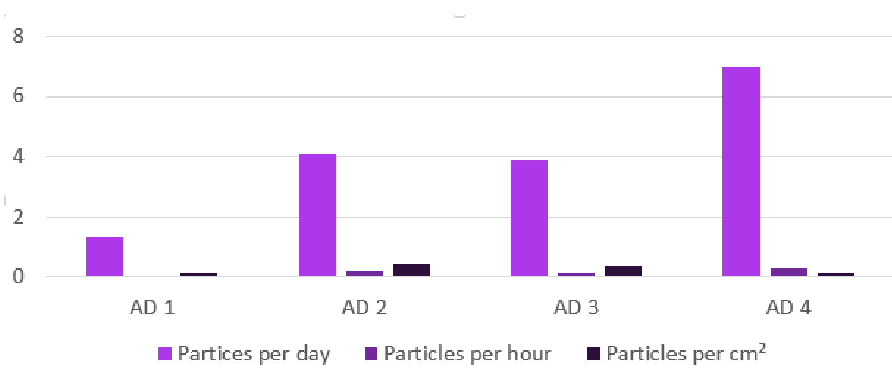

Figure 5. AD samples.

suggests that large plastic items are entering the river from city pollution and degrading. This could be from storm sewers or direct pollution into the river. The only comparison to other studies that can be made to Sites A-D would be that other studies have also found the majority of particles to be fibres. (Gasperi et al., 2018).

The Source Investigations showed likely sources of the microplastics polluting the river. Snow samples also showed large numbers, up to 9.5 particles per litre of snow from an urban driveway. These particles are mostly the result of atmospheric deposition throughout the winter. This is another reason for the suggestion that atmospheric deposition is a leading pollutant here.

Polymer particles were found in all AD samples. The highest levels per hour inside were found in a household living room (AD 2) with 0.17 particles per hour. This was also the highest traffic location. The highest levels per hour in all of the samples was the one from an urban backyard (AD 4) with 0.29 particles per hour. These are the particles that can potentially be entering the river. It is uncertain whether this is a significant number. Since the particles per hour are below one, It is believe that the samples were not affected by atmospheric contamination. I found only fibre particles in the AD samples. Other researchers have found that while fibres are the dominant pollutant, irregularly shaped particles are also in atmospheric deposits. (Cai et al., 2017).

Microplastic ratios in TAP water were consistent through all of the samples, except for TAP 2 which had a 400% increase to the two other samples of the same volume. The TAP samples were only taken from one faucet, this leads to the need for further study, to understand if this is a city-wide issue.

Tap water, which was used to rinse Sites A-D, contained higher amounts of microplastics per litre than those samples, with an average of 0.09 particles per litre. Due to the low volume of tap water used to rinse and process the samples, less than one particle would be added. Rinsing with tap water was likely not a pathway for contamination, though it may be polluting the river.

The origin of the particles in the Source Investigations is unknown. It is suggested that atmospheric deposition is the greatest pollutant to the river but there is no evidence these particles are local. It is possible that they have drifted across the globe and settled here. The local tap water is sourced from groundwater, there is very limited air contact in the water system. It is possible that these particles may be seeping into the groundwater from the river, though it is unlikely.

CONCLUSION

In conclusion, there are microplastics in the Yukon River. The sources seem to be filament fibres from atmospheric deposition, and possibly tap water. The atmospheric pollution may not even be local, these particles could have originated from anywhere in the world. Currently, there is no simple way to trace the particles back to their original source.

Hypothesis 1 was mostly incorrect, as the most microplastics were found at Site A, instead of Site D as I had hypothesized. It was originally believed that there would be no microplastic pollution at Site A. As well, It was found that a higher water velocity reduced the amount of time for accumulation on the water, instead of carrying more particles. The hypotheses were correct in that there would be a greater number of fibrous particles.

Hypothesis 2 was mostly correct. Overall, the greatest number of particles were found in the SNOW samples. AD samples showed presence of airborne microplastics which I had hypothesized. TAP samples were much different than I had expected. I had hypothesized that there would be no particles in the TAP samples but microplastics were found in all samples.

Microplastic pollution is a worldwide concern. Microplastics cause harm to wildlife, (Lehtiniemi et al., 2018) and human health. (Robertson, 2018). Not only are the plastics doing harm, the additives and the chemicals that absorb into them are also a threat to the environment. (Gasperi et al., 2018). Microplastics can be found almost anywhere, from the water we drink to the river we fish in.

Further Study

the following changes would be considered before further research in this study:

- Take many more samples of snow, river water, tap water, and air, to be able to perform a proper analysis.
- Compare this study's results with a wider variety of studies.
- Reduce pathways for contamination.
- Sample at locations with similar water velocities (Sites A-D only).
- Test more blank samples.
- Rinse samples with properly filtered water.
- Take springtime samples for comparison.
- Use a filter with a grid for easier counting.
- Ensure wastewater is discharging while I am sampling downstream.
- Trace the origin of the airborne particles.

Community Awareness: A Note from the Author

I began growing awareness about microplastic pollution in Yukon. Since this is pioneering research, I felt it was my responsibility to publicize my findings. I worked with three local organizations, Zero Waste Yukon, Raven Recycling, and the Yukon Conservation Society. These are three concerned groups, excited to help publicize our campaign. I created a poster for print (Fig.3), as well as one for social media. These include information about the risks of microplastic, as well as actions for people to consider. Those include hanging your clothes to dry, buying clothes made of natural fibres, and investing in a microfibre catching laundry ball or washing machine filter.

I also had a meeting with Whitehorse Mayor and Council, this was a great opportunity to get my message to our government. I have also met with Environment Yukon employees who are interested in beginning microplastic research of their own.

Awareness is the first step to reducing Whitehorse's microplastic discharge into the environment.

ACKNOWLEDGEMENTS

Thank you to all those who have helped me by providing tools and support for my project.

- Justine Ammendolia - Memorial University
- Bruce Bennett - Environment Yukon
- Jeff Bond - Yukon Geological Survey
- Jenny Bonny - F.H. Collins Secondary
- Bryna Cable - Various supports
- Stephen Chastain - Ocean Wise
- Laurissa Christie - Various supports
- Julia Duchesne - Yukon Conservation Society
- Mary Gamberg - Gamberg Consulting
- Hayley Hung - Northern Contaminants Program
- Liisa Jantunen - Northern Contaminants Program
- Heather Jirousek - Environment Yukon
- Meghan Larivee - Environment Yukon
- Chelsea M. Rochman - Assistant Professor Department of Ecology and Evolutionary Biology University of Toronto
- Whitehorse Mayor Dan Curtis and Council
- Shaun McLoughlin - F.H. Collins Secondary School
- John Minder - Environment Yukon
- Rhiannon Moore - Researcher, Ocean Pollution Research Program
- Randi Mulder - Environment Yukon
- Nicole Novodvorsky - Water Quality Technologist Environment Yukon
- Gerry Perrier - Yukon Government
- Kim Porter - Various supports
- Geoff Quinsey - Manager, Water and Waste Services, City of Whitehorse
- Lewis Rifkind - Yukon Conservation Society
- Remy Rodden - Manager, Environmental Education and Youth Programs, Environment Yukon
- Arcadio Rodriguez - Senior Technologist, Water and Waste Services, City of Whitehorse
- Andrea Sidler - Biologist
- Grace Snider - Various supports
- Joy Snider - Raven Recycling
- Pat Tober - Environmental Dynamics Inc.
- Ira Webb - Zero Waste Yukon
- Leyla Weston - Yukon Geological Survey
- Matthew Wilkie - Environment Yukon

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BRUCE PORTER

I am a 14-year-old, Grade 9 student from Whitehorse, Yukon.
I have participated in two Canada-Wide Science Fairs and this is my second article published in the *CSFJ*. I also recently attended the MILSET Expo Science International in Abu Dhabi. Science has given me so many opportunities! The *CSFJ* has provided an audience for me to share my findings with. Most recently, I have been working on microplastic research in Yukon. This is something that affects all of us, so it is very exciting to share it across Canada!