

Honours 2025/2026 Proposal

Title: Detection and removal of microplastic contamination in Kamloops municipal compost

Introduction (background and rationale for the project):

The City of Kamloops has recently implemented a residential curbside pickup program for residential food and organic waste. Bins are collected and now locally composted in Kamloops at Grassland Organics composting facility.

Compositing is a natural process that uses microbes like bacteria and fungi to help break down organic matter like food waste into a usable fertilizer for agricultural purposes. Composting improves nutrients retention, soil fertility, as well as improving plant microbe symbiotic relationships to improve plant growth, reproduction and yield (Heisey, 2022;Pathma, 2012). Composting occurs under aerobic conditions whereas when food waste ends up in landfills, anaerobic bacteria take over which releases more methane into the atmosphere which is 25 times stronger than carbon dioxide (Aljarrah, 2024). Therefore, composting food waste as an alternative method for food waste collection is one of Kamloops climate action goals.

There are three phases of composting that differentiate composing from landfill degradation, and they are the mesophilic, thermophilic, and maturation phase. During the mesophilic phase, temperature and CO₂ increase and the degradation of sugars and proteins begins (Pan, 2012). In the second phase, the thermophilic phase, the temperature increases from about 45-70°C, and at about 50°C thermophilic bacteria take over (Pan, 2012). This high heat kills off most pathogens and is an optimal range for microbial activity, which is why it is also referred to as the 'active phase' (Papale, 2021). In the third phase, the maturation phase, also known as the 'curing phase', the temperature decreases to about 37°C and there is low oxygen

consumption (Papale, 2021). In this phase, organic materials continue to decompose for some time until the compost is mature (Papale, 2021). A longer curing phase is especially important when toxic organic acids and other resistant compounds are present so they can be stabilized during this phase (Papale, 2021). Having a longer curing phase could potentially be important in the degradation of tough microplastics polymers. This project intends to test and follow the three temperature phases of composting and samples from each phase will be studied.

Kamloops's Residential Waste Collection program has had great success so far. However, improvements can be made when it comes to inorganic contaminants. One primary contaminant that is found in compost is plastics. Plastic contamination can come from careless and uneducated disposal from residence, but also from micro and nano plastics already present in the food we eat. Microplastics, which are plastics that are less than 5mm in size (Porterfield, 2023) pose a potential health and environmental threat. Microplastics that are present in compost can leach through agricultural systems when used as fertilizers. These micro and nanoplastics are able to move within the food chain and be transferred from soil, to plants, animals and humans (Mattsson, 2015). It has been found that micro and nanoplastics can cause toxicological effects on all living things including plants, animals, microbes and humans and they distribute throughout the ecosystem. In recent studies it is found that micro and nanoplastics accumulation in the human body causes digestive, inflammatory, pulmonary, cardio, and cellular metabolism issues (Yee, 2021).

Unfortunately, it takes about 100-1,000 years for plastics to degrade in an environment (Pilapitiya, 2024). However, recent research has found that some microbes are able to produce extracellular enzymes that are able to break up complex plastic polymers into usable sources for microbial energy (Othman, 2021).

Objectives:

- 1) Detect and characterize microplastics and nanoplastics in Kamloops municipal compost using techniques such as UV-Vis spectroscopy, Coulter counter analyzers, Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Capillary electrophoresis (CE), Matrix-Assisted Laser Desorption/Ionization-Time of Flight (MALDI-TOF) mass spectrometry, Atomic Force Microscopy (AFM), Raman spectrophotometry, as well as optical and fluorescent microscope imaging to identify the type/size and amount of microplastics
- 2) Investigate microorganisms and their roles in degradation of microplastics and nanoplastics
 - Grow multi-bacterial batch culture of plastics degrading bacteria in plastic polymer enrichment media in the lab
 - Metagenomic sequencing of bacteria able to degrade plastic from lab grown cultures and compost field samples
 - Test trial partnered with Waterloo University using their plastic degrading microbial enzymes in a lab setting enrichment media
 - *On site* field test trial at Grassland Organics using the isolated plastics degrading bacteria if time permits

Materials and Methods:

All samples of compost will be collected from Grassland Organics, the local composting facility in Kamloops. One sample collection will be taken from a compost pile of about one month old and has already gone through the grinding and screening process. This sample will be used to determine the type of plastics common in Kamloops compost and perfect the sample preparation method for the first few weeks of the study. Another compost pile will be the project's isolated pile that will be used throughout the duration of the experiment. For the

continued use of this pile, a small sample will be collected within the first few days, and another sample will be collected every month. This pile will be used to track the plastic degradation rate, the abundances of the different types of plastic throughout the composting processes, as well as the different types of bacteria present and their abundance after each month.

Objective#1: Detect and characterize microplastics and nanoplastics in Kamloops municipal compost

Once the compost samples have been collected, they will be prepared for microscopy and spectroscopy analysis all using the same method after every month of collection. The sample will be dried in an incubator at 60°C overnight and sieved through a 5mm sifter. About 1g of the compost will be added 30% hydrogen peroxide to degrade the organic material and allowed to degrade for 24 hours. UV-Vis, Raman and optical, and fluorescent microscopy analysis will be done on the compost samples after every month of compost maturation. The results of these tests will help in determining the abundance of microplastics in the compost over time. In addition, Raman, AFM, CE and ICP-MS analysis will provide information about the plastic polymer type that is most common in Kamloops compost.

Objective#2: Investigate microorganisms and their roles in degradation of microplastics and nanoplastics

For the microbial degradation test, compost of different maturation ages will be added to separate batch cultures of enriched media that has plastic polymers as the sole carbon source. The polymer type used to enrich the media will be based on the Raman, AFM, CE and ICP-MS results potentially showing the most common type in the samples collected. If bacteria are able to grow in this environment, it would suggest that the bacteria already present in the compost are able to grow and use plastic as an energy source

Another enriched media experiment will be set up with compost added and the addition of the pFAST-PTEase enzyme from Waterloo University to aid in plastic degradation.

For both enriched media conditions, a comparison of plastics degradation will be done using UV-vis, Raman, and optical and fluorescent microscopy following the same method in the spectroscopy and microscopy analysis.

Metagenomic analysis will also be performed to determine the most abundant bacteria throughout the composting process. From the list of bacterial species abundance, the results will be compared with metagenomic sequencing results from the enrichment media growth with and without the addition of the enzyme. From there, bacteria that are able to degrade microplastics naturally and with the addition of the pFAST-PTEase enzyme can be used in further experiments for industrial use.

Permits:

No permits are required to complete this project.

Expected results:

We expect the results of this project to conclude by using the spectrometry instruments, the amount of microplastics will decrease in the compost over time. The decrease in microplastics will be from the ability of the bacteria already present or from the addition of the pFAST-PTEase enzyme, to break down the plastic polymers into other carbon macromolecules that can be metabolized for energy.

Timeline:

Month	Plan
May-July (Goals according to Mitacs grant)	Spectrometry and microscopy analysis of plastics in compost
September (Microbial)	<ul style="list-style-type: none"> - Start growing bacteria in lab with the addition of the polymers to the media - On going spectrometry/microscopy on compost samples
October-December	<ul style="list-style-type: none"> - Bacterial growth with addition of pFAST-PTEase enzymes from Waterloo - Spectrometry/microscopy on bacterial degraded sample - Spectrometry/microscopy on compost samples
January-February	<ul style="list-style-type: none"> - Metagenomic sequencing of batch cultures (have samples sent in by January latest) - Analyze results in February, depending on how long it takes to get results back from UBC - Being writing thesis (methods) - Honours project update (January)
March-April	<ul style="list-style-type: none"> - Compile results for spectroscopy/microscopy and metagenomics and make conclusions - Thesis writing/publication (have draft complete by mid-March) - Poster presentation (end of March) - Oral defense of thesis (April)

- Spectroscopy/microscopy analysis will be continued each month (from May 2025-May 2026) for further projects results

Budget:

Item	Cost
30% hydrogen peroxide	\$ 31
Lab consumables	\$ 100

Spectroscopy reagents	\$ 100
DNA extraction kit	\$ 400
Metagenomic sequencing	\$ 3,000
Plastic polymers	\$ 55
TOTAL COST =	\$ 3,686

The expenses above for this Honours project will be covered by the awarded Mitacs Accelerate Grant (Application ref.: IT44307 Funding request ref.: FR143131 - Awarded April 25, 2025) of \$5,000 and Kamloops Climate Action Grant (ROMEO file # 104409) of \$2,000 by Dr. Naowarat Cheeptham and Dr. Anusha Venkatarman. Additional Mitacs Accelerate grants of up to \$5,000 for each application will be applied for.

Literature Cited

Aljarrah M, Ashraf A, Khandakar A, Rohouma W, Ayari MA, Esmaeili A, Butt R,

Kadampotupadeth S, Thomas K, Rahman A, et al. Environmental performance analysis of three organic waste disposal scenarios: landfilling, composting, and EP-50. *Discover Sustainability*. 2024 [accessed 2025 Feb

13];5(1):445. [https://link.springer.com/article/10.1007/s43621-024-00614-](https://link.springer.com/article/10.1007/s43621-024-00614-7)

[7#:~:text=Organic%20waste%20breaks%20down%20anaerobically,lowers%20methane](https://link.springer.com/article/10.1007/s43621-024-00614-7#:~:text=Organic%20waste%20breaks%20down%20anaerobically,lowers%20methane)

[%20emissions%20%5B18%5D](https://link.springer.com/article/10.1007/s43621-024-00614-7#:~:text=Organic%20waste%20breaks%20down%20anaerobically,lowers%20methane). doi:<https://doi.org/10.1007/s43621-024-00614-7>.

Porterfield KK, Hobson SA, Neher DA, Niles MT, Roy ED. Microplastics in composts, digestates, and food wastes: A review. *Journal of Environmental Quality*. 2023 [accessed 2025 May 21];52(2):225–240.
<https://access.onlinelibrary.wiley.com/doi/full/10.1002/jeq2.20450> doi:
<https://doi.org/10.1002/jeq2.20450>.

Nayanathara Thathsarani Pilapitiya PGC, Ratnayake AS. The world of plastic waste: A review. *Cleaner Materials*. 2024 [accessed 2025 May Feb 13];11:100220.
<https://www.sciencedirect.com/science/article/pii/S2772397624000042#:~:text=The%20degradation%20rates%20of%20plastic,of%20fish%20in%20the%20oceans>. doi: <https://doi.org/10.1016/j.clema.2024.100220>.

Othman AR, Hasan HA, Muhamad MH, Ismail N 'Izzati, Abdullah SRS. Microbial degradation of microplastics by enzymatic processes: a review. *Environmental Chemistry Letters*. 2021 [accessed 2025 Feb 23];19(4):3057–3073.
<https://link.springer.com/article/10.1007/s10311-021-01197-9>. doi:
<https://doi.org/10.1007/s10311-021-01197-9>.

Mattsson K, Ekvall MT, Hansson L-A, Linse S, Malmendal A, Cedervall T. Altered Behavior, Physiology, and Metabolism in Fish Exposed to Polystyrene Nanoparticles. *Environmental Science & Technology*. 2015 [accessed 2025 Feb 23];49(1):553–561.
<https://pubs.acs.org/doi/10.1021/es5053655>. doi:<https://doi.org/10.1021/es5053655>.

Yee MS-L, Hii L-W, Looi CK, Lim W-M, Wong S-F, Kok Y-Y, Tan B-K, Wong C-Y, Leong C-O. Impact of Microplastics and Nanoplastics on Human Health. *Nanomaterials*. 2021

[accessed 2025 Feb 23];11(2):496.<https://pmc.ncbi.nlm.nih.gov/articles/PMC7920297/>.
doi: [10.3390/nano11020496](https://doi.org/10.3390/nano11020496).

Pan I, Dam B, Sen SK. 2012. Composting of common organic wastes using microbial inoculants. NIH. [accessed 2024 Feb 23]; 2(2): 127-134.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3376866/>. doi: [10.1007/s13205-011-0033-5](https://doi.org/10.1007/s13205-011-0033-5).

Papale M, Romano I, Finore I, Giudice AL, Piccolo A, Cangemi S, Meo VD, Nicolaus B, Poli A. 2021. Prokaryotic Diversity of the Composting Thermophilic Phase: The Case of Ground Coffee Compost. NIH. [accessed 2024 Feb 23]; 9(2):218.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7911569/>. doi: [10.3390/microorganisms9020218](https://doi.org/10.3390/microorganisms9020218).

Pathma J and Shakthivel N. 2012. Microbial diversity of vermicompost bacteria that exhibit useful agricultural traits and waste management potential. SpringerOpen. [accessed 2024 Feb 23]; 26.<https://doi.org/10.1186/2193-1801-1-26>.

Heisey S, Ryals R, Maaz TM, Nguyen NH. 2022. A Single Application of Compost Can Leave Lasting Impacts on Soil Microbial Community Structure and Alter Cross-Domain Interaction Networks. Frontiers. [accessed 2024 Feb 23]; 2.
<https://doi.org/10.3389/fsoil.2022.749212>.