Title: Using compost to reduce cardboard waste and exploring the relationships microbes play

Abstract: (1500 characters)

This project aims to reduce cardboard waste through composting throughout the City of Kamloops. Partnering with the City of Kamloops, this project will look into if cardboard has any impact on compost microbial diversity. In Canada large quantities of cardboard end up in landfills and are responsible for an increase in greenhouse gas emissions. Recycling cardboard is also an energy and water intensive process. Therefore, composting cardboard could be an alternative way to reuse cardboard. Composting also has beneficial agricultural impacts and the microbial community in the compost can aid in crop yield. The methods to compare the microbial diversity in compost containing cardboard and compost without, will be observed through microbiology culturing techniques like spread plating, plate counting and Gram staining. Additionally, 16S rRNA amplicon sequencing will be done to determine the microbial diversity between all comspot samples. The use of ICP-MS will also be used for a chemical analysis on the cardboard used and compost to determine if the elements found in them have an impact on the microbes present.

Literature Review: (3500 characters)

Composting is a natural process of recycling nutrients back into the soil that involves microbes like bacteria and fungi that decompose organic matter from food and plant waste and turn it into a usable fertilizer.

Composting improves soil nutrient retention, creating better soil conditions for agricultural purposes. Additionally, the soil microbiome can also increase soil conditions and fertility (4). Compost with an increased microbial community composition balances the soil ecosystem and improves the health of the soil and plants (8). Many microbes share a symbiotic relationship with plants and aid in plant growth and yield, nutrient uptake and nutrient cycling. Therefore, having more bacterial and fungal diversity within the compost results in a preferable compost for agricultural use (8).

There are three phases of composting, the mesophilic, thermophilic and maturation phase. During the mesophilic phase, temperature and CO2 increases and the degradation of sugars and proteins begins (6). In the second phase, the thermophilic phase, the temperature increases from about 45-70°C and at about 50°C thermophilic bacteria take over (6). 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’ (7). 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 (7). In this phase organic materials continue to decompose for a period of time until the compost is mature

(7). 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 (7). Having a longer curing phase could be an important aspect in decreasing the effect of toxins found in cardboard.

The overarching goal of this project is to tackle the issue of cardboard recycling. In Canada, 85% of old corrugated boxes are recycled, however this still results in a high percentage that ends up in Canadian landfills (9). The cardboard that is recycled goes through the recycling process which requires large amounts of water by using a hydrapulper to break down the material (10). Environment Canada stated that it takes about 324L of water to produce 1kg of paper (2). Using cardboard as a bulking agent in compost can help reduce the cardboard that ends up in landfills and reduce the water consumption required in the recycling process.

Additionally, cardboard that ends up in landfills contributes to the large amount of greenhouse gas emissions released into the atmosphere. In Canada methane gas from landfill contributes to 20% of the national methane emissions (5). Greenhouse gas emissions are an important concern that must be regulated in order to reduce the impacts of climate change.

Cardboard is an important element to this project and there are two main types of cardboard. The first is corrugated cardboard which is thicker and has an additional wavy fiber. In households, corrugated cardboard are typically items like often shipping or packing boxes. The second type is paperboard or chipboard cardboard, which is made up of thin short recycled fibers and are typically items like cereal boxes and pop cases (3). This project intends to test both corrugated and paperboard cardboard because they are both common types of cardboard found in most residential households.

Another focus for the type of cardboard will be looking to see if cardboard with heavy dyes, glue and glossy finishes have any impact on the microbial community. The glue used for corrugated cardboard is starch glue which is biodegradable and environmentally friendly (11). However, little research has been done to see how microbes interact with other toxins found in cardboard like diisobutyl phthalate which is a common chemical found in cardboard printing ink (1).

Research Question: (500 characters)

Is it recommended to use cardboard in composting to enhance microbial diversity and reduce cardboard waste in landfills, and if so are all types of cardboard safe to use?

Methodology: (1500 characters)

Composting will be done in two locations. One will be in a laboratory setting where outside variables can be controlled. Additionally, a test trial will be set up at Aero Environmental which is where Kamloops residential organic waste is sent for composting.

A control treatment of compost that does not contain cardboard will be used to compare against compost that contains cardboard. Further experiments will be done to look at the effects of different types of cardboard and the toxins they carry. There will be a test trial of compost that contains ink, glue and dye contaminants to see if these toxins have any effect on the microbial diversity and the compost products.

For all test trials of cardboard and non-cardboard compost samples, microbial culturing methods will be used to observe the growth of the bacteria and fungi. Compost samples will be spread plated and nutrient agar and potato dextrose media. From these plates CFU will be counted to determine the amount of bacteria present in each sample, as well as Gram stains and methyl blue staining will be done to observe the bacteria and fungi present and determine the variation and similarities between samples.

To aid in the culturable results DNA will be extracted from each compost sample and sent to UBC for sequencing of the 16S rRNA which will be amplified and analyzed through PCR and amplicon sequencing. The results of the amplicon sequencing will help determine the genera of bacteria and overall microbial diversity in each compost sample.

For this project a chemical analysis will also be performed on the compost samples and the cardboard itself using ICP-MS. The results of the ICP-MS will help to determine what elements are most common in the compost and cardboard, which may lead to further inquiries about how they may influence the bacteria and fungi present.

Impact on the field of study: (1500 characters)

This project is a community driven research project, the results of the study will have a direct impact on the city of Kamloops waste program and local residents. This study has the potential to impact neighboring communities that may also be interested in reducing cardboard waste in their landfills by sharing the results of the project. The results of this experiment will also shed light into the limited research on how cardboard influences microbes in composting. The results will help the city of Kamloops determine if recycling cardboard is the only way to dispose of it or if composting it is another alternative with additional benefits.

Dissemination: (500 characters)

If the results of this study show an increase in microbial diversity with the use of cardboard in composting then the city of Kamloops will continue their initiative in telling residents to add cardboard layers in between their at home organics bins and create a new movement to encourage the use of cardboard in compost as a way to reduce the amount that ends up in landfills. The hope is that a report will also be published in a scientific peer-reviewed journal and that the results will be shared at the ASM conference in 2025.

Academic and Professional Goals: (1000 characters)

My aspirations are to have a positive impact on the world around me using my knowledge and scientific background in microbiology to create lasting change that benefits either the environment or the health of others. I want to pursue a career in research so I intend going to graduate school either in Canada or Europe.

The opportunity of doing this UREAP project is a great way to get experience starting an original project from the beginning to end and being in charge of the preparation, methodology and analysis that goes along with doing academic research. This project is also special in the sense that it can have a direct impact on my community and be implemented right away, which is very inspiring and the type of research I would love to continue to do.

Timeline:

The timeline for this project may vary depending on the continuation and exploration of different avenues and the results of the experiment. However, I do intend to summarize the results to align with the timeline of the UREAP summer term. The timeline will align with how long the city of Kamloops may want to continue the project. A full year will be ideal so that we can look at how the change in seasons impact composting

April:

- ICP-MS training
- Fine tune methodology
- Visit Aero Environmental

May:

- Begin setting up composting trials
- ICP-MS on cardboard being used

June:

- Continue the composting procedure (aerate the compost)

July:

- Continue the composting procedure (aerate the compost)

August:

- Prepare samples for DNA extraction
- ICP-MS on compost

September:

- Analyze 16s rRNA gene sequencing

Budget:

UREAP Budget - Additional Costs		
Travel Costs		
Applicant		
Research Travel - Canadian & Foreign**		
Airfare	**$**	**-**
Mileage	**$**	**-**
Accommodations	**$**	**-**
Per Diem	**$**	**-**
Per Diem Rate & Accommodation		
TOTAL	**$**	
Supplies		
Publication expenses	**$**	**-**
Office supplies	**$**	**-**
Technical and Transcriptional services	**$**	**-**
Small Equipment	**$**	**-**
Laboratory Supplies		
Field Supplies		
Other Expenses (please specify)	**$**	**-**
Conference Registration	**$**	**-**
	$	**-**
	$	**-**
Total Supplies Costs	**$**	**-**
TOTAL AMOUNT REQUESTED		

#REF!

- Bins - $40.00
- Nutrient agar - $35.00
- Potato dextrose agar - $35.00
- DNA extraction kits, PCR agents and DNA sequencing fee - $3,000.000

References: (3500 characters)

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