

UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

UBC Farm

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CHBE 363

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CHBE 363: UBC SEEDS Project

UBC Farm

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Abstract

This project is a UBC SEEDS project focusing on the UBC farm, with the primary objectives concerning the compost pile. The client, Andrew Rushmere at the UBC Farm, needs to determine how the compost piles negatively affect the environment with respect to greenhouse gases—particularly methane. If it is determined that there is a significant effect to the environment from the compost then the next step is to research and recommend practical solutions to the farm. An alternative objective of the project is to research and recommend solutions to the farm with respect to the quality of the compost; the feed materials of the compost are poor in nitrates which are crucial in plant development. It is decided that gas chromatography (GC) is the most effective and available scientific method to quantify the greenhouse gas emissions.

The first step for the analysis is to collect samples from the compost. The first attempt to collect and test samples failed, but the methods of collecting were refined so that more confidence could be held in the obtained results. As methane production would likely occur more in the center of the compost pile (due to anaerobic conditions), a long 1.5” PVC pipe was used to extract deeper samples. This time, samples were stored in better sealing bags and one sealed glass container. While the second attempt at the GC did not work with the better sealing bags, the glass container did yield results with methane. However, these results are extremely difficult to quantify as the method to extract the gas from the container involved exposure to the environment.

The most feasible recommendation that can be made to the farm is flipping the compost more often to increase aeration for a more aerobic environment. Another solution researched is to consider sending the compost to the UBC composting facility, as they have a fully aerated process which is unsuitable for methane production. To improve the compost quality, legumes can be planted on the compost and mulched in because legumes are inexpensive and produce nitrogen compounds. An alternative to legumes is alfalfa meal, which can be purchased in stores. To reduce leaching of nutrients caused by rainwater washing, the compost can be covered with a tarp. This solution will also help insulate the compost during the winter months from convective and radiative heat losses, which may help in the winter composting rate. Future students continuing this project will need to use better sealing containers and get more sample readings to better quantify the results. The farm staff can be contacted to acquire a temperature profile of the compost to better determine the conditions needed to incubate the samples for a gas analysis.

Introduction

The UBC SEEDS program is an initiative by the university to develop the following in a sustainable and non-environmentally damaging way: air, water, energy, financial, food, human, land and materials. What makes the SEEDS program unique is that its development is shared between students, faculty members, and the staff of the institutions in cooperation with SEEDS. This dynamic is key for innovation as each party involved has a significantly different knowledge base and perspectives to contribute to the success of a SEEDS project.

The scope of this project is with respect to the UBC farm. Often called Vancouver's last working farm, the current location of UBC farm occupies 24-hectares near UBC's south side of campus. The primary uses of the UBC farm include teaching, research, and community use. The location of the first UBC farm was developed in the early 1900's in the area that is now known as West Mall. This was in part a response to the demand of the timber in the UBC area. It was after the efforts of clearing the area that the initial farm location was chosen. Currently, the biggest notable achievement of the farm is its ability to produce field-scale production levels of food, fibre, and fuel, which is key to developing sustainable food and land practices. The focus of this project is in regards to the sustainability to the environment of the compost at the UBC farm. It is desired to quantify the levels of greenhouse gases produced by the compost. The motivation is that it is suspected that due to the limited amount of oxygen reaching deep into the compost, anaerobic activity is predominant resulting in methane production. Methane is a substantial greenhouse gas which also possesses an energy value worth exploiting. Secondary objectives of the project are in concern to the compost composition as well as the loss of nutrients to the environment resulting from rainwater run-off. This can cause ground water contamination and reduced levels of nutrients in the compost. The composition of the compost at the farm is poor in nitrates due to the primary sources of feed, which include animal bedding, coffee cups and grinds, and waste organic material from and near the farm. Compost lacking in nitrates is undesirable because it leads to poor growth conditions.

Problem Definition

The focus of this project deals with the UBC farm's compost. At the UBC farm, compost is sorted and separated into different piles with a concrete retaining wall and several subdividing sections. Residence time of the compost is the determining parameter that categorizes the separated piles. Primary sources of feed for the compost are mainly saw dust from animal bedding, coffee grinds and coffee cups, as well as various sources of waste organic material located near or on the farm. The animal bedding comes from an animal testing facility and to maximize the cleanliness of the animals, the bedding at the facility is changed frequently and therefore has very little time to absorb nutrients that comes from the animals or their waste. To facilitate better composting, the UBC farm 'flips' or mixes the various piles of compost, which aids in maintaining constant composting conditions.

The first objective of this project is to determine the negative effects on the environment due to green house gas emissions of the compost. To do this, it is first desired to determine if greenhouse gases are emitted from the compost piles and secondly if they are produced in a quantity that has negative effects on the environment. If methane is detected from the compost then research and recommendations of practical solutions to the farm to reduce the effect of the emissions will be carried out. Further objectives of the project are to research already existing solutions to help improve the composition of the compost. The feed to the compost is lacking in nitrates, which is crucial to plant development, so it is desired to find methods of increasing the nitrates to improve the compost pile. Furthermore, the compost has low biological activity during the winter resulting in poor composting.

If any of the above mentioned objectives do not come to fruition in the time frame of this project, recommendations will be made to students in following years so that the objectives can be completed in the future.

Methodology

For the methodology section of this report there are three parts. The first section discusses the field experimental techniques along with the modifications. The second and third sections go into detail about the techniques and the apparatus used in the GC and Micro GC analysis.

Field Experimental Techniques:

The first step in our project was to collect samples from the compost. These samples were tested to find out the composition of the gases produced. The first time the samples were collected Ziploc bags were used, both the zipper and the sealable type. The procedure for collecting the samples is simple; reach into the compost with the Ziploc bag collect the sample and seal. The samples were then taken back to UBC and incubated in an oven inside a fume hood at representative condition of the compost. These representative conditions are determined to be 50°C for four days, we chose 50°C because this is approximately the internal temperature of the compost pile.

However, with this procedure problems were encountered. The first and most significant was that the zipper Ziploc bags did not form a sufficient seal. When the gases were produced they escaped out of the bags. Another problem was with taking the sample by hand. In doing this we were only able to get sample from the top layer of the compost. With these issues in mind we came up with a modified procedure to collect the second set of samples.

To collect the second set of samples, a 1.5'' diameter 6' long plastic tube was used to extract the samples. This was very effective and allowed us to collect samples from different layers of the compost, most importantly the anaerobic center layer. Figures 3 to 5 in the appendix are photos illustrating this step. Again the samples were emptied into the sealable Ziploc bags, and taken back to be incubated at UBC. One of the samples was transferred into an air tight glass container in an attempt to reduce the escape of the produced gases. The samples were incubated at almost the same temperature (45°C) for 7 days and then the gas composition was tested.

GC Experimental Apparatus:

The gas samples released by the incubated compost samples are collected in a syringe. Several microliters of the collected samples are injected into heated injection port of the Gas Chromatography (GC) Unit (Figure 1).



Figure 1 : Gas Chromatography (GC) Unit

The GC in this gas detection process is operated by using nitrogen as carrier gas at 100°C. The injected sample is vaporized into the flowing carrier gas stream. GC uses column temperature which detects gases by polarization, boiling point, and molecular weights. Therefore, every little difference in physical properties allows the components to be separated.

A computer continuously monitors detector signals that can be plotted. These plots of GC detector signal as a function of retention time are called gas chromatograms. The area under a given peak is proportional to the relative quantity of the respective component that is present in a given test sample.

Micro GC Experimental Apparatus:

Gas analysis by using Micro Gas Chromatography (Micro GC) uses the exact same procedure as GC. Gas samples from the incubated compost samples are collected in a syringe and 1 ml of the sample is injected to Micro GC. Micro GC used in this analysis is CP-4900, and manufactured by Varian, INC. It uses molesieve module and ultra high purity grade argon as

carrier gas. The Micro GC with this carrier gas only detects hydrogen (H₂), oxygen (O₂), nitrogen (N₂), methane (CH₄) and carbon dioxide (CO₂). This channel is optimized for low level hydrogen analysis.



Figure 2 : CP-4900 Micro GC with Optional Field Case

The Varian CP-4900 is controlled by Varian Galaxie software and injector: The CP-4900 uses a gas sample loop that is etched into a silicon wafer. The internal volume of the loop is 10 μ l and sample volumes of 1 to 10 μ l can be selected using the Galaxie software. Each module contains one main analytical capillary column ten meters in length and one pre-column identical in composition to the analytical column but much shorter in length (approximately 2 meters). The columns are housed in an oven that can be set to temperatures ranging from ambient to 180° C. The temperature which was chosen to analyze the compost gas samples is 110°C.

The CP- 4900 analyzes complex gas samples using the selectivity of up to four independent GC channels. Each GC channel, with a different column phase, simultaneously separates a different subset of sample components. Micro GC consists of the single or dual sample inlets, pumps and optional gasifier for volatile liquids and pressurized gas streams. Therefore, CP-4900 is capable of handling a wide range of sample types and its features make micro GC a useful tool in determining gas concentrations from a sample.

Results and Discussion

The main objective of this project is to determine the green house gas emissions of the compost pile. In addition, an overall environmental analysis including the composition of the compost is also studied.

The gas composition of the compost is obtained by analyzing several samples using a gas chromatography (GC) apparatus. Two batches of samples are obtained from the UBC farm. The samples in the first batch are taken by hand from the surface of the compost and are placed in Ziploc zipper bags. The samples are incubated in a laboratory oven at representative conditions of the farm compost, at 50°C for 4 days to simulate the process through which gases are produced in the real compost. After incubating the samples they are analyzed with the GC equipment. After running the experiment the gases of most interest, methane and carbon dioxide, are not found in any of the samples.

Since no methane is found in the first batch a second batch of samples, more samples must be examined from the farm using refined experimental techniques. Instead of taking the samples from the surface of the compost, the samples are taken from the center of the pile in order to perform an analysis of the most anaerobic section of the compost. The samples are then taken from the center using a 6' long and 1.5" diameter tube and are placed in Ziploc bags. One of the samples belonging to the first pile of the compost is placed in a glass container while the remaining samples are kept in the sealable bags. Once again, the samples are incubated at 45°C for 7 days and analyzed using micro GC. The extended incubation period is because the Micro GC needed maintenance prior to the analysis.

Using this procedure, green house gases methane and carbon dioxide are found in the sample taken from the first pile which was incubated in the glass container. However, the rest of the samples failed to show the presence of these gases. The gas composition of the sample placed in the glass container are found to be 77.34 mol% nitrogen, 0.21 mol% methane, and 0.18 mol% carbon dioxide while the remaining gases are oxygen and water vapour. A graph is obtained from the micro GC showing the results of the experiment (see figure 6 in Appendix). As it can be seen in the plot, the existing gases are detected at different times by showing a peak in the graph. The largest peak, which appears between 0.4 and 0.5 min, belongs to nitrogen since it is the most abundant gas in the sample. The peaks belonging to methane and carbon dioxide cannot be seen

in the graph due to the low concentrations of these gases in the sample. Only by doing a close-up zooming in of the graph the small peaks are realizable.

Even though methane and carbon dioxide are proven to be present in the compost, the significance of their concentrations still remains unclear. It is extremely difficult to know whether these numbers represent a considerable amount of green house gases produced. This is because at the time of changing the sample from the Ziploc bag to the glass container, air is allowed to come into contact with the sample and with the gases inside the container; therefore, most of the gases detected are only nitrogen and oxygen. In order to obtain a more precise and meaningful examination, both gases must be quantified relative to the other gases present in the compost or in the sample.

Several sources of error and reasons why samples failed to show presence of greenhouse gases are found throughout the experiment and the overall project. The first and probably most important thing to consider is the lack of appropriate containers to hold the samples. Ziploc sealable bags are not the best method since they do not seal completely and tiny holes can be found across the surface of the bag after handling. Therefore, the gas produced by the sample has a way of exiting the container; in addition, this also allows for air to come into contact with the sample creating a mixture of mostly air in the container. This is why the first batch of samples as well as the second batch of samples (the ones placed in the bags) failed to show any existing methane and carbon dioxide. Furthermore, the GC apparatus used in the first trial is not suitable for detecting light gases such as methane. The columns found in this apparatus are only designed to detect gases that have similar molecular weight to that of oxygen. Therefore, methane and carbon dioxide, which are lighter gases than oxygen, could not be detected by the equipment. Moreover, since the first batch of samples was only taken from the surface, the samples are not a good representation of what actually happens inside the compost. Hence, the second batch of samples is taken from the anaerobic center.

Reflections on UBC and Sustainability

UBC as a campus is committed to sustainability. The goal for the UBC Campus Sustainability Office is to “focus our minds on creating a university infrastructure that runs as sustainably as possible”¹. The UBC SEEDS program is “Western Canada’s first academic program that combines the energy and enthusiasm of students, the intellectual capacity of faculty, and the commitment and expertise of staff to integrate sustainability on campus”².

In our SEEDS project, our main objective is to determine the composition of greenhouse gases produced from the UBC Farm’s compost. By doing this we are able to gain real life experience and a foundation in place for next year’s SEEDS students to quantify the gas production. If the greenhouse gases (methane and CO₂) produced are in large amounts, actions can be taken to implement a feasible solution for capturing the gases. Capturing the gases will contribute the campus’ sustainability goals to be as environmentally friendly as possible.

Another objective in our SEEDS project is to address the issue of leaching. Leaching causes nutrients to be washed out from compost and can lead to pollution of ground water. As a group we came up with a number of possible solutions to this problem that would eliminate the leaching runoff contaminating ground water and reducing the compost’s nutrients.

This experience has taught us a lot about sustainable thinking. As the purpose for this project, our objectives and methods were developed with sustainability in mind. As a first exposure to its practices for all the group members, this project has taught us to think more about environmentally safe practices in our daily lives as well as to see areas that could be improved to be more efficient or less damaging. As student engineers, we believe this is an extremely useful lesson, as it will continue to be our responsibility to continually improve the area in which we live as well as pass on our knowledge to younger generations of engineers.

¹ Reference 5

² Reference 7

Recommendations for the UBC Farm

The objective of the SEEDS project is to implement solutions which contribute to increasing the efficiency and effectiveness of the operation of composting at the UBC farm. Problems that the farm faces include methane production, low quality compost, leaching during fall and winter seasons, and reduced winter composting. Below will be an in depth look into each dilemma, and our suggested implementations to fix or minimize the issues.

Methane Production

Methane is a gas produced and released into the atmosphere from the compost because the gas production of methanogens which thrive in an oxygen poor environment. Typically, a compost pile undergoes aerobic decomposition as opposed to anaerobic decomposition. With complete oxygen penetration a compost produces CO₂ instead of methane. If a compost pile is taken care of properly it releases far less methane into the atmosphere.

For the UBC Farm, we can minimize the methane production by creating a more aerobic environment by turning the compost more frequently. (The only issue with turning the pile more frequently is the compost's inner temperature might decrease significantly. This will be discussed in the reduced winter composting section). Another solution is to pump air through pipes to the bottom of the compost. This way we can ensure the microorganisms receive a sufficient amount of oxygen to undergo aerobic decomposition. A completely different idea altogether is to determine the capacity and logistics of sending the UBC farm compost to the aerated UBC compost. These methods are also both efficient and sustainable, and can contribute in the long term reduced methane production.

A more complicated solution is to isolate and capture methane. This can be done by placing a greenhouse or a sealed environment over the compost pile to isolate and trap gases. The greenhouse will cover an area of 20 x 40 ft or more to the client's preference in order to cover all of the compost. A gas pump can then be placed into the greenhouse to remove the gases trapped inside and send the gases to a gas separation unit. The captured methane can be used to heat facilities at the farm or produce energy.

Low Quality Compost

A major problem with the UBC farm compost is that it's rich in carbon but lacking in nitrogen. A high nitrogen to carbon ratio is extremely important in compost because it determines the quality of the compost as a fertilizer and the health of microorganisms for compost decomposition. Carbon supplies energy in carbohydrates and nitrogen provides growth in proteins and microorganisms in the compost need these elements to survive.

An effective solution would be to plant legumes on the compost. The soil on the second and third compost piles (which have been composted extensively) are optimal for planting legumes. Legumes are classified as a plant which develops their seeds in a pod. Legumes have symbiotic bacterial colonies that change nitrogen in the air to a solid form stored in the plants roots. Sweetclover is one of the most suitable legumes to plant in the compost because they can grow almost all year round and have some of the highest nitrogen content per gram of plant [10]. Sweetclover seeds should be inoculated with proper strains of nitrogen fixing bacteria before planting. Sweetclover is best planted in the early spring in moist conditions. Sweetclover should develop for at least 60 days before mulching into the compost for maximum benefits [10]. A greenhouse placed over the compost will lengthen the growing season.

For Vancouver's climate snow peas would also be an effective legume to plant in the compost. Snow peas are nitrifying and prefer cooler climates allowing them to grow throughout the winter. Snow peas sprout very quickly, within 6 days, so even with the compost being turned regularly the nitrifying benefits would still be noticeable. To produce a fully mature plant it takes around two months. Planting the seeds is very simple, take one seed and push it into the soil approximately 1.5 inches and place the next seed 6 inches away, being sure to water regularly. Plant the seeds closer for shorter rotations of snow peas on the compost.

As well, fertilizers such as cottonseed meal and alfalfa meal can be placed into the pile to increase nitrogen in the compost. Both the fertilizers and legume seeds can be bought in stores.

Leaching

During the fall and winter rainfall is more common and since the compost pile is not covered, leaching occurs. As a result, the nutrients from the compost are taken away and ground water can also be contaminated as well.

An effect solution would be to cover the compost with a greenhouse or a tarp. This way the compost is covered completely and leaching will no longer be an issue. The tarp would have to cover an area of 20 x 40 ft in order to cover all of the compost. A tarp will reduce convective and radiative heat losses helping to trap more heat in the compost and raising the compost temperature nearly 4°C throughout since a typical compost generates approximately 200W/m³ of heat energy [11]. Another suggestion is to divert and utilize the runoff by creating a gravity trench. This way the high nutrient runoff water can be used as a spray fertilizer for crops.

Reduced Winter Composting

During the winter, temperatures are low and can cause reduced biological activity resulting in slow composting. Compost heat is produced as a by-product of the microbial breakdown of organic material. Heat production depends on the size of the pile, its moisture content, aeration, and carbon/nitrogen ratio.

Solutions that can heat up the pile can include mixing the pile more frequently, increasing moisture, or placing a tarp/greenhouse to insulate and prevent heat loss. Currently the piles are rotated every 2-4 months and an analysis of when the temperature of the pile decreases is needed so the pile can be turned as required (will be described below).

Decomposition occurs most rapidly during the thermophilic stage of composting (40-60°C) which can last for several weeks or months depending on the size of the system and composition of the compost. This stage is also important for destroying thermosensitive pathogens, weed seeds, and fly larvae.

Eventually the compost begins to cool, so turning the pile usually will result in a new temperature peak because of replenished oxygen supply and exposure of organic matter not yet thoroughly decomposed. This is when turning the compost is most effective.

Recommendations for Future CHBE 363 Groups

Compost Environment

The first steps of the continuation of the UBC farm SEEDS project should involve consulting with the client at the farm to gather the temperature profile data of the compost available. The temperature profile data will be useful when incubating compost samples at representative conditions. Additionally, the optimal time to flip the pile to maintain the maximum decomposition (related to maximum heat production) of the pile during the winter periods can be determined from this data. Studies should be conducted on the compost that quantifies the effects of moisture on methane production and to determine the aerobic and anaerobic layers of the compost. It will be possible to quantify the effects of moisture on methane production by taking deep compost samples and adding or removing moisture from the sample before incubating and performing a Micro GC analysis. Furthermore, methane is produced in an anaerobic environment from methanogens so it is recommended to collect samples from every layer of the compost to determine the methane producing layers. This data will be important when scaling up the methane generation rate of a sample to the compost scale of methane generation.

Sampling Methods

Samples need to be extracted from the surface to the deep internal layers of the compost. In order to extract these layers it is recommended to use a sample core method as is used in the Earth's crust. A 6 foot and 1.5 inch diameter plastic pipe is appropriate for sampling. As the pipe is twisted into the compost a sample is extracted into the core which can be removed from the pipe by pushing the sample out from the opposite end with a long object or tapping the pipe with a branch.

The samples should be stored and incubated in sealable glass containers. In order to extract gases from inside the container, the lid of the container can be retrofitted with a rubber grommet by drilling a small hole into the lid and placing the grommet through the hole. A grommet is a standard automotive part and will provide a sufficient seal. The center of the grommet can be punctured with a needle to purge the sample with a neutral gas before incubation to create an anaerobic environment and the needle hole can be plugged with a larger object

afterwards. After incubation the gas inside the container can be extracted using the needle for Micro GC and puncturing the grommet once again. The grommet is only good for limited use but it is easy to replace. If specialized gas bags are available it may be possible to incubate the samples in these containers and allow expansion of gases to occur without increasing the container pressure substantially. Normal plastic bags are fragile and do not provide a sufficient seal.

Incubation

The samples extracted need to be stored in an environment that allows gas production at representative conditions of the compost. Samples should be incubated in a laboratory oven at the temperature of the layer they came from between one to two days to allow sufficient gas production. Place the oven in a fume hood to reduce odours in the laboratory. Samples from the core of the compost are approximately from an anaerobic environment between 40°C to 50°C. Additionally, an accurate temperature profile is available from the farm. Samples suspected to be from an anaerobic layer should be purged with nitrogen gas to simulate anaerobic conditions during incubation.

Methane Production

The Micro GC analysis provides a concentration value for the methane produced by the sample. It is possible to approximate the number of moles in the container by using the ideal gas law to find the number of moles of gas present in the container at the start of incubation. The mole percentage of methane reported from the Micro GC can be used to give an estimate of the number of moles of methane in the container. More accurate measurements are only possible if the pressure in the container is known after incubation. Knowing the number of moles of methane in the container and the time of incubation, a rate of generation of methane as a function of time can be calculated. By knowing the dimensions of the compost and understanding which layers of the compost are methane producing (from measurements of samples at different layers), one can give a rough estimate of the methane generation rate scaled up to the compost scale.

Methane Capturing Solutions

Since methane is a greenhouse gas which has an energy value, it is desirable to capture the methane and utilize it. Investigations into current technologies could inspire methane capturing solutions feasible for the farm. Methane capturing is practiced in the industry at facilities such as wastewater treatment plants and landfills. Technologies can be benchmarked from the industry and applied to improve proposed farm methane capturing solutions. Investigation into gas separation is also required and a full life cycle analysis of any proposed solution needs to be conducted.

Feasibility Study

Lastly, a feasibility study needs to be conducted on the methane capturing project. The study will consider factors such as the technological, economic, and operational feasibility of the proposed solution. The technology study will assess whether the farm has the capability in terms of hardware, personnel, and expertise to handle successful completion of the project. An economic study will provide a cost/benefit analysis to determine the benefits and savings expected from a possible solution and compare them with capital and operating costs. The benefits to the farm and the environment need to outweigh the expenses. Methane capturing will provide a source of energy to the farm and will reduce the impact of methane as a greenhouse gas on the environment. This study is the most important and will assess whether the amount of methane produced is financially worth exploiting. The operational study will measure how effectively the solution captures methane and meets the clients' objectives. The study will also assess whether the farm is capable of operating the solution and upkeep on maintenance.

Conclusion

There are four main problems that required solutions at the farm. Firstly, there was an ambiguity as to whether methane gas is being released to the environment from the decomposition of the farm compost. Apart from that, the compost which is being produced in the UBC farm lacks nutrients and mostly contains carbon. As a result, the compost is of low quality and has a reduced value as a fertilizer. Another main problem faced by the farm is nutrient leaching. Due to the lengthy rainy season in Vancouver, the open air compost is often exposed to rain water. The rain water drains out the nutrients from the compost. Finally another concern of the farm is that winter composting could not be carried out efficiently as the temperature becomes extremely low for decomposition to occur significantly.

Being the first group to do this project we lacked data on the gas compositions of the compost. We decided to perform GC analysis to know if methane is being released from the compost. We took some samples from the UBC farm compost and brought it back to the Chemical and Biological Engineering (CHBE) lab and incubated it for four days at a temperature of 50°C. From performing the GC we realised that there was no methane found in the samples. This could have been due to the errors in handling and analysing the samples such as keeping the samples in a non-sealed container, keeping it for a very long time in the incubator and using GC machine instead of micro GC. Thus, we went back to the farm and collected more samples and one of the samples was placed in a tightly sealed glass jar. All samples were incubated at nearly the same conditions as before and we performed micro GC. The Micro GC analysis was able to detect the methane gas that is being released from the sample and thus we conclude that methane gas is being released from the UBC farm compost.

To solve the problem of lack of nutrients in the compost, we propose a solution of planting legumes which would increase the nitrate content in the compost. Using cottonseed meal would also be helpful in increasing the nutrient level. Covering the compost with a tarp would prevent rain water from draining out the nutrient content of the compost. The tarp would also help insulate the compost the winter. In order for composting to be carried out during winter, we suggest to the UBC farm to build a greenhouse. A greenhouse helps to increase the temperature and thus composting can be done effectively even during winter season. A simplified version of a green house would be sufficient for this purpose. Also, the piles can be

mixed more frequently as this will also help to heat up the compost from increased microbial activity.

Besides coming up with solutions to the problems faced by the UBC farm, we have also suggested some ideas for the next year UBC farm team in order to give them a narrowed scope to handle the problem. Providing future teams with the data obtained from this project will help the project be successful and from our experience it is hoped that they could proceed from where we finished. A few suggestions that we came up with are to use a long 6ft long 1.5” diameter plastic tube to extract deep compost samples to get into the anaerobic layer found within the compost. Also, incubate samples in sealed glass containers that have a rubber grommet placed through lid would ensure that the gases from the compost do not escape out, but gas extraction could be effectively carried out with a needle. This is because, during our first trial to perform GC, the containers we kept our samples in were not tight enough and as a result, the gases escaped and our first GC was not able to indicate the presence of methane. Also the samples should be incubated at a temperature between 40⁰C to 50⁰C and be kept in the fume hood. This is because the compost makes the laboratory smell as the samples incubate.

Overall we have managed to develop solutions for most of the problems that the UBC farm faces such as leaching, winter composting, and lack of nutrients in the compost. However we were only able to prove there is methane production from the compost and unable to quantify the amount of methane being released. Thus, the next step in this project is to quantify the amount of methane that is being released. By quantifying the amount of methane being released it can be determined if solutions to capture methane are feasible technologically, economically, and operationally. If the methane is being produced in large amounts the next step would be to come up with feasible solutions to capture methane.

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Appendix

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Photos:



Figure 3: First cell at the Farm's Compost heap (before turning)



Figure 4: First cell at the Farm's Compost heap (after turning)



Figure 5: Second sample collection techniques

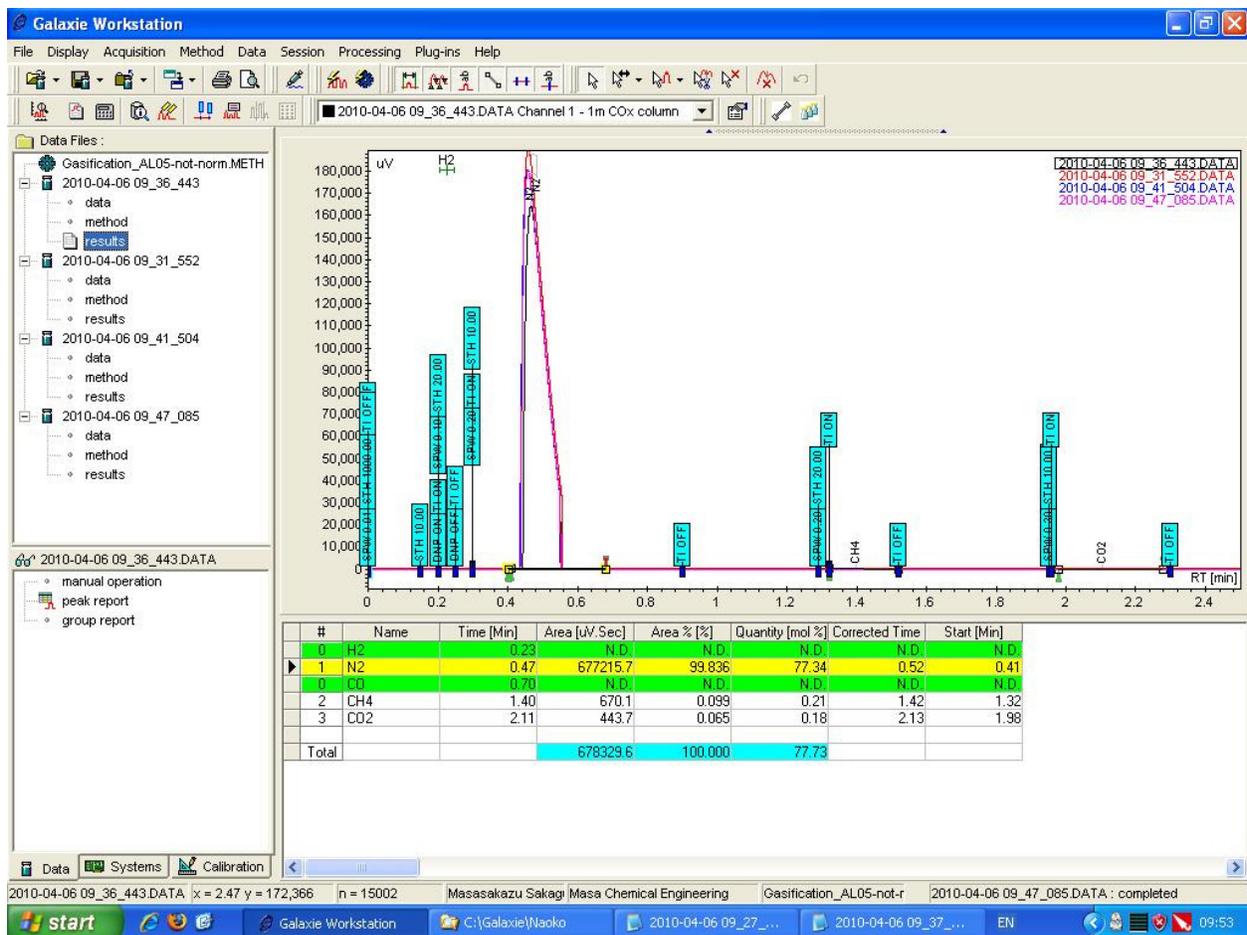


Figure 6: Micro GC results for the sealed container on trial 2. Methane composition is 0.21mol%.