Mission Folder: View Mission for 'GreenHouse Gals'

State	Illinois
Grade	6th
Mission Challenge	Alternative Sources of Energy
Method	Scientific Inquiry using Scientific Practices
Students	

Team Collaboration

(1) Describe the plan your team used to complete your Mission Folder. Be sure to explain the role of each team member and how you shared and assigned responsibilities. Describe your team's process to ensure that assignments were completed on time and deadlines were met.

Teamwork:

The three of us are all in the same class in the same school. We all really love science and have many shared interests. We were very excited and interested in starting a science project together.

Mind Mapping and common interests:

Before we started our composting research, we started creating a mind map. This mind map expressed all of the problems that are present in our community today. Some ideas that were on our mind map included hunger, money, fossil fuel use, landfill waste accumulation, and more. We all started work on a single large white board writing out our 'interest bubbles'..... discovering that compost was a central idea that helped knit our thoughts together. As a team, we discovered the main problems compost could potentially fix, and discussed many new ideas together.

Weekly Work Plan:

Our team had meetings about once a week. Every meeting, we would assign tasks for the week to each team member that they would work on our composting research document. For the following meeting, we would discuss what new things we learned about and share/ brainstorm ideas.We made a shared document called the Compost Research Document, in which we would write who had what assignment.

Research and Experimentation:

We all went to the library and each took two books that we would read and write essays about. We learned a lot more about composting from reading these books, and learned more about the process. When we were creating our wooden compost bin, we each took turns learning to build: drawing, budgeting, purchasing, measuring, sawing and nailing the wood. We created a heat exchange compost experiment together. Each of us had a certain task to do. One person took the temperature, one kept track of time, and the other wrote the recordings down. During our meeting, we also discussed future ideas together and worked as a team to collaborate.

Roles During Presentations:

During our Powerpoint Slide Presentation to the mayor of Lisle, North Central College, and Benedictine, we decided that we should each have an equal amount of time talking. We distributed the slides equally among ourselves, each getting 3-4 slides to create and present.

Time management:

Each week, we would have an assignment due at our next meeting. We organized our meetings by working on our research for the first hour or so, and for the rest of our time, we would do experimentation. We combined our research on a weekly basis and discussed what we learned new.

Collaboration:

We used google docs as a collaboration unit. We structured our collaborative work document the same way as our mission folder. This way, we kept track of our meetings, hypotheses, our experimentation, our finds and conclusions just the same as for our mission folder.

Conclusion:

Because we put our composting research document in this structure, it made it easier to create the format for our final mission folder document and we were confident of completing it on time.

Scientific Inquiry

Problem Statement

(1) What problem in your community did your team investigate? Why is this problem important to your community?

The problems that face our society in this era are mainly struggles of social and environmental origins and are usually complexly interwoven into each other. The problems we are investigating and trying to solve with our submission are the excessively large amounts of food and yard waste that end up in landfills around the whole nation. When we look at individual & city wide problems, we see the damage done by artificial fertilizers, harming marine life and waterways. We also are looking into the limited availability of fossil fuels that are impacting our environment. Compost is a great multi-faceted solution to this problem that no one has really used yet. We want to turn compost into a real source of heat energy that can be used for households around the nation.

In the entire nation, the average amount of food & yard waste found in landfills is about 28% of its total load, which shows that unnecessary space is being taken up. This is obviously detrimental to the environment, but it has many drawbacks that affect our everyday, such as waste haulers having to drive farther to offload household waste, in turn increasing the cost of our garbage sticker, and tax prices. Overuse of artificial fertilizers is another large scale issue we are targeting, that hits close to home. In our research, we learned that artificial fertilizers lead to toxic runoff which spikes water pollution rates, as well as altering plant life, and poisoning soil. Just last year, America's very own Lake Erie was suffering with huge amounts of algal growth because of homeowners, and unsuspecting farmers overusing fertilizers that had growth boosters and biological inhibitors. The runoff of the fertilizer supplemented eclipsing algae blooms that cause blockages in waterways, like in the Mississippi, and kill other flora and fauna in water bodies where they grow. These are some of the issues that we face in our industrializing world, but have no sustainable solution as of today.

Out of all the problems, we decided that the most pressing is the lack of renewable energy sources and finding sources that can be extracted without excessive environmental damage.

For example, fossil fuel usage and extraction has significant impact to the the environment, including CO2 emissions, aquifer contamination etc. As human population expands, it will be harder to identify and find renewable energy sources.

The idea of compost as a potential energy source is alluring because of its significant environmental benefits while at the same time, producing energy as a by-product. Compost as an energy source has not been widely used, researched, or implemented. We will run out of fossil fuels at the current rate of consumption, but as long as there is food, yards, and such sources of organic waste, we can't run out of compost. The heat that compost produces can be harnessed and used as an alternative renewable source of energy.

(2) List at least 10 resources you used to complete your research (e.g., websites, professional journals, periodicals, subject matter experts). Use multiple types of resources and do not limit yourself to only websites.

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http://www.homecompostingmadeeasy.com/carbonnitrogenratio.html-Cortesia Sanctuary, C. Forrest McDowell, PhD and Tricia Clark-McDowell. "The Carbon/Nitrogen Ratio." The Carbon/Nitrogen Ratio. N.p., n.d. Web. 16 Jan. 2017.

https://www.planetnatural.com/composting-101/making/what-to-use/-Https://www.facebook.com/PlanetNatural. "What to Compost (Ingredients)." Planet Natural. N.p., n.d. Web. 16 Jan. 2017.

https://web.extension.illinois.edu/homecompost/science.cfm--"The Science of Composting." The Science of Composting - Composting for the Homeowner - University of Illinois Extension. N.p., n.d. Web. 16 Jan. 2017.

https://www.planetnatural.com/composting-101/making/c-n-ratio/ Https://www.facebook.com/PlanetNatural. "Carbon-to-Nitrogen Ratio." Planet Natural. N.p., n.d. Web. 16 Jan. 2017.

http://www.cityfarmer.org/recipe.html - the perfect compost recipe "Wet & Dry, Brown & Green." Composting Recipe. N.p., n.d. Web. 16 Jan. 2017.

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Cummings, Dede, and Cheryl Wilfong. The Organic Composting Handbook: Techniques for a Healthy, Abundant Garden. New York, NY: Skyhorse, 2014. Print.

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https://www.scientificamerican.com/article/how-fertilizers-harm-earth/ "How Fertilizers Harm Earth More Than Help Your Lawn." Scientific American. N.p., 13 July 2009. Web. 16 Jan. 2017.

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Smith, Kelly M. How to Build, Maintain, and Use a Compost System: Secrets and Techniques You Need to Know to Grow the Best Vegetables. Ocala, FL: Atlantic Pub. Group, 2011. Print.

http://compost.css.cornell.edu/physics.html Trautmann, Nancy. "Compost Physics - Cornell Composting." Compost Physics - Cornell Composting. Cornell University, n.d. Web. 16 Jan. 2017.

(3) Describe what you learned in your research.

In all of our composting research, there are three main things that we can take away: The process of composting, its ability to give off heat, and the amount of waste diverted from landfills.

Household scale of compost and benefits:

Compost can be created at a household level; We each took ownership of managing a compost pile during the duration of this project, and found that they were very easy to maintain, as all we had to do was water and turn the pile, and add food scraps every once in awhile. Platypus 777's family noted that after they started composting, they cut down to ? of the garbage they had previously been producing, because they were able to compost ? of it. That amount of trash would not be filling space in a landfill, and thus kept landfills open for the most "last resort" items that could not be reused.

Aquifer contamination is another risk that comes from landfills. When there is a lot of accumulated trash, the liquids from it can seep through the ground and get to our aquifers if not managed well. This leads to the aquifers being contaminated with lots of chemicals, negatively affects human health because humans consume the water in the aquifers.

We saw how compost can energize a garden, and supplement it in a natural way, as well divert organic material from a landfill where it will never complete the nitrogen cycle and in turn augment more plants to grow to their maximum potential, Household cost saving:

When people compost, their garbage output to landfills is reduced to about 1/2 the amount they usually accumulate. Platypus 777's family calculated their savings, and on garbage stickers alone, saved 117$ in 1.5 years. They have come very close to breaking even, and paying off their compost bins.

Composting is scalable:

We found from our meetings with both North Central College, Naperville IL, and with Benedictine University, Lisle, IL that composting activity can be managed on a larger scale. Both the Universities had managed their compost collection using Garden Prairie Organics. Garden Prairie carted away the compost from their dining facilities and spread it on their nursery farm and converted it to high quality organic compost that they sold back to villages, municipalities, golf courses and home owners.

We also learned that the Morton Arboretum was a ready reservoir for large amounts of outside compost and compostable material (Large amounts of heat!!), and would be a good place to contact, as they are not afraid of managing their on-site compost, they actually welcome it.

Our team also did a lot of research on other cities that do composting on a large scale. We looked into Seattle, San Francisco, and Columbus large scale composting, and how they collect homeowners' compost.

The science of composting:

There are two different types of compostable material: mainly carbon, or nitrogen rich materials. Browns and Greens for short. There is a specific ratio of ~27 Carbons to 1 Nitrogen, and if it is compromised, then odor will permeate the yard, and decomposition will slow down. Pests are uncommon unless a composter puts meat or dairy into their pile. We know that on a small scale, some people do not believe in the power of compost, yet there are many examples of successful city-scale composting as we mentioned in the scalability section.

We did research into the different types of compost piles, aerobic and anaerobic, and how the microbe cycle is different in each type of pile. Compost can divert a about 28% of waste from landfills, consisting of food and yard waste.

Another thing we did to look into compost was talk to Ralph Osier from Osier Advanced Tree and Yard. Raph is a professional soil scientist and gave us some tips about composting. Ralph said that people put all of their compost because it smells great and they think it will look awesome. In reality, too much compost will make the phosphorus levels go through the roof. If you put the right amount which is about ¼ inch every fall, the microbes in the compost will help the soil make more nutrients while not overloading the soil and creating insect and soil problems.

Heat recovery from compost:

The most dramatic and inspiring topic that our team looked into was the ability of compost to produce energy/heat. We realized that we could use that heat as a substitute for fossil fuels. Compost is an earth-friendly, renewable heat source. We started mapping out different experiments that we could do and ideas like heating up a shed with the heat from compost.

Our team learned a lot about the decomposition and cycle of composting. We learned about the different microbes and bacteria that generate heat as the food and yard waste in the pile breaks down. There are two main types of bacteria that are involved in the decomposition in compost, mesophilic and thermophilic. Mesophilic bacteria decompose the compost material by producing acids, carbon dioxide, and heat. After the temperature of the pile rises higher than 100 degrees fahrenheit, the thermophilic bacteria come in. Thermophilic bacteria continue the decomposition process. This is when the compost is at its highest temperatures. When the thermophilic bacteria die off, the pile starts to cool down.

This is the best time to harvest the heat that compost gives off. If we take the heat when the compost is at it's highest temperatures, we will end up disturbing the bacteria, so the best time to use the heat is when the pile's temperature is decreasing.

Our visit to the landfill made us aware of all the risks that landfills carry. In a landfill, so much heat is created from the decomposition of trash, that it is a real danger. The heat from inside the landfill can lead to threats such as subsurface oxidation. Subsurface oxidation is a process where there is immense heat inside the landfill. If the landfill is disturbed or is exposed to oxygen, there could be spontaneous combustion inside the landfill, creating air pockets & dangerous dips. This could happen in a compost pile too. If compost sits for a long time, there is so much activity in the middle of the pile that when the pile is disturbed or turned, the oxygen exposure leads to spontaneous combustion and fires.

Hypothesis

(4) State your hypothesis. Describe how your hypothesis could help investigate your problem.

We believe that large-scale composting can play a role as a cleaner energy source by harvesting the compost heat. This could replace or supplement the use of other non-renewable fuels.

We believe that the heat from a compost pile can be harvested easily and efficiently. We hypothesize that with the right tubing choice and a low flow pump, and water, it would be possible to create and measure the transfer of heat from a hot SOURCE (e.g., compost) to a colder SINK (e.g, greenhouse shed, garage or warehouse concrete slab etc.).

Please see specific hypotheses for each Experiment Nos. 1, 2 and 3 attached

(5) Identify the independent variables and the dependent variables in your hypothesis.

As composting is part of a natural biological process, there are a number of independent variables:
Size of pile
Shape of pile
Position of pile
Material in pile
Moisture of pile
Turning rate

The dependant variables:
Decomposition Rate (time taken to complete composting)
The Duration of time that the heat can be extracted

Amount of heat produced
Smell of Pile

In real life, the larger external conditions are the Control Group and Constants. In our experiments, we are able to move more of the Independent Variables into the Constants category.

Time of year/weather conditions when pile is built
Location (Exposure of Pile to direct sunlight)
Type of composting (aerobic vs. anaerobic)

Please see attachments for three separate experiments: Experiments #1, #2 and #3 that document the individual variables for each experiment.

(6) When you developed your hypothesis how did you know it could be tested AND could be proven false by testing?

We set up a series of experiments to verify the heat produced by a compost pile. If a small compost pile in the middle of a Midwestern winter produces heat consistently, then we feel a larger city-scale pile could definitely be more successful.

We subsequently set up controlled experiments to simulate a heat exchanger and understand the efficiency of heat transfer possible from using simple materials.

This experiment would demonstrate how the heat that compost can give off could be captured and moved from the 'source' to a 'sink'. We put hot and cold water in two bins side by side, hot water representing compost, and cold water representing a slab or a shed and ran pipes through them.

The cold water went through the pipes, absorbing the heat from the hot water. We looked into different pipes that were cost effective, and had good conductivity. We also acquired a low cost, low flow, submersible pump so that the water would constantly be moving. We kept measurements on time and temperature. This experiment models a big compost pile, and how it could be used to heat up a floor, green house shed, etc.

We then changed the composition and set up a revised experiment to more fully simulate a compost pile. We believed that if this heat transfer happened in a reasonable amount of time, then this could be a commercially successful idea.

Experiment 1:

When we first built our two compost piles, we wanted to see if compost had the potential to rise to high temperatures. We tested this experiment by monitoring our two compost piles, checking the temperature regularly to see how the temperature changed. We knew that this could be proven false because we weren't aware yet if the compost pile would be able to sustain itself in the cold of winter and even give enough heat to act as a substitute source of energy.

Experiment 2:

We wanted to set up an experiment to demonstrate how the heat that compost gave off could be taken and transported from a source to a sink. We put hot and cold water in two bins side by side, hot water representing scalding compost, and cold water representing a slab or a shed and ran PEX pipes through the two bins. The cold water went through the pipes, with the pipe making the heat go through the pipe wall and into the cold water. We looked at different pipes that were cost effective and had good heat conductivity. We also acquired a low cost, low flow, submersible pump so that the water would constantly be moving. We kept measurements on time and temperature so that we could look at the results in a graph after the experiment was done. Our hypothesis for this experiment could have been proven wrong if the heat exchange took an inordinately long time to transfer heat from hot to cold.

Experiment 3:

We replaced hot water with compost in this experiment, to be a more accurate simulation of real conditions. Our hypothesis is that we wanted to be able to harness heat from compost. We did this, and transferred the heat to cold water from the hot compost. We expected the temperature of the compost pile to be inconsistent in different areas because of the nature of compost. This experiment could have possibly proven our hypothesis wrong if we found that the heat transfer using compost was very slow and did not effectively exchange the heat from the compost to the cold water.

Experimental Design

(7) List the materials you used in your experiment. Include technologies you used (e.g., scientific equipment, internet resources, computer programs, multimedia, etc.).

Please see attachments for three separate experiments Experiments #1, #2 and #3

(8) Identify the control group and the constants in your experiment.

Please see attachments for three separate experiments Experiments #1, #2 and #3

(9) What was your experimental process? Include each of the steps in your experiment. Include all safety precautions used by your team as step one.

Please see attachments for three separate experiments Experiments #1, #2 and #3

Data Collection and Analysis

(10) Present the data you collected and observed in your testing. The use of data tables, charts, and/or graph is encouraged.

Please see attachments for three separate experiments Experiments #1, #2 and #3

(11) Analyze the data you collected and observed in your testing. Does your data support or refute your hypothesis? Do not answer with a yes or no. Explain your answer using one of the following prompts: 'Our data supports/refutes the hypothesis because...'

Please see attachments for three separate experiments Experiments #1, #2 and #3

(12) Explain any sources of error and how these could have affected your results.

Please see attachments for three separate experiments Experiments #1, #2 and #3

Drawing Conclusions

(13) Interpret and evaluate your results and write a conclusion statement that includes the following: Describe what you would do if you wanted to retest or further test your hypothesis. Evaluate the usefulness of the data your team collected. What changes would you make to your hypothesis and/or experimental design in the future, if any?

Please see attachments for three separate experiments Experiments #1, #2 and #3

Uploaded Files:

- [**View**] **Field visits and sustainability visits** (By: Advisor, 02/21/2017, .pdf)
  A visit to the Green Valley landfill to understand landfill technology and environmental risks. A visit with The Sustainability Coordinator of North Central College in Naperville, IL to discuss large-scale composting.
- [**View**] **Experiment #1** (By: Advisor, 02/21/2017, .pdf)
  A hypothesis, methodology, inquiry and conclusions from an experiment on compost heat
- [**View**] **Choice of Heat Exchange Tubing** (By: Advisor, 02/21/2017, .pdf)
  Research into conductivity, cost, puncture resistance, and other factors to determine the ideal choice of tubing for Experiment #2 on heat exchange.
- [**View**] **Experiment #2** (By: Advisor, 02/22/2017, .pdf)
  A hypothesis, methodology, inquiry, and conclusions from an experiment on compost heat exchange
- [**View**] **Experiment #3** (By: Advisor, 02/22/2017, .pdf)
  A hypothesis, methodology, inquiry, and conclusions from a revised experiment on compost heat recovery using a heterogeneous compost mix substituted in the hot SOURCE.

Community Benefit

(1) How could your experiments and data help solve your problem and benefit your community? Describe next steps for further research/experimentation and how you have or how you could implement your solution in the future.

The benefits of composting are crucial and can be felt from a unit as small as a single household to a scale as large as a major city. Compost is one of those rare activities that have benefits on many levels and on many scales. Soil benefits, financial benefits, agricultural productivity benefits and heat recovery are all great assets of composting. We embarked on a series of meetings with universities, local governments and potential large scale composters to confirm their interest in supporting the idea.

The Mayor’s Office, Village of Lisle, Illinois:

On Feb. 9th, 2017 we met with the Mayor; Mr. Joe Broda of Lisle, and learned a few things about politics. We found out that the city didn’t just pay Waste Management every time they came around but the town actually had a long-standing contract with the waste hauler. Lisle has been riding on this current contract for about 5-7 years but there are only 2 years left till a new one must be signed. This is a negative side effect for our project, because we can’t do it for the next 2 years because he has to sign a new one in 2019 so we have to wait for that time to come before we can implement that idea. Also, if more and more people are making huge mountains of garbage every few years, all the landfills in our area will be filled. Then, the waste haulers will be forced to drive farther away from where they pick up the garbage. This means that the gas prices and vehicle fees will get higher as the landfills get farther from where we live. This also means that our garbage stickers will become more expensive because the prices that we have to pay for the waste hauler is also going up.

Then, we learned that if we were to implement this idea into our community, we would have to be cost efficient. Finding a cheap, inexpensive way to pick up the compost from people’s house was one of the most important parts. Space was also relevant; where would we put the compost? Finally, the Mayor gave us a great suggestion. Why not put an article into the Lisle Green Newsletter? It was read by about 21,000 people so it was quite a prominent magazine. If we published in there, we would definitely have some listeners that would hear out our pleas and start their own backyard composting.

Benedictine University and Sustainable Saturday:

On Feb 16th, 2017, we met with Prof. Jean-Marie Kauth, Sustainability Coordinator at Benedictine University. Jean-Marie welcomed our proposal to distribute a flyer on the benefits of composting on Sustainable Saturday.

Sustainable Saturday is a recycling program at Benedictine University where residents of Lisle and neighboring villages come to drop off their electronic and other recyclable goods. Hundreds of people gather up at the University for the drop off. Since so many people come there, we have decided that we want to design a flyer or pamphlet that will inform people about composting. The Mayor encouraged us to spread the word about composting. More and more people will be encouraged to start & we can save the environment, one household at a time.

On Saturday Mar 18th, GreenHouseGals will release our flyer “TRASH TALK” for distribution.

Morton Arboretum and Garden Prairie Organics:

One of our next steps would be contacting the Morton Arboretum. When Lisle picks up the yard waste, they don’t have a public space to put it so they give it to the Morton Arboretum, who actually needs it. We would like to talk to the Morton Arboretum about the leaves and if they compost them at all. Also, we want to contact Garden Prairie Organics. At Garden Prairie Organics, they have countless rows of compost which are constantly steaming. Garden Prairie Organics also sells compost for home planting. Talking to Garden Prairie Organics and Morton Arboretum are big next steps because they can provide us with some great insight on large scale composting as well as commercial composting. We decided that if the mayor was unable to kickstart our curbside compost pilot, then we should look at organizations that were actively dealing with compost, and try to ask them if we could work on our heat exchange on a larger scale.

Kennedy Junior High School and SCARCE:

Next, we want to contact SCARCE, a recycling and environmental education organization that teaches kids like us about the Earth. We want to invite them to Kennedy to possibly educate the students at our school about composting and what it can do for the Earth. If we can teach more kids about composting, they will go home and instead of throwing away their extra lunch, they will throw it in a compost bin and not only save money, but also the Earth, in the long run.

Grants and Funding:

When we traveled to Benedictine University, Prof. Jean-Marie Kauth told us about the F-SCRAP grant, a grant provided by the state of Illinois. The F-SCRAP grant will provide us with funding for the village of Lisle so that Lisle can start incorporating composting into their weekly garbage and recycling rounds. We would also like to invest in copper piping for future experiments so that we can get even more heat from the compost.

The Future of Composting… It’s Out of This World:

Another future step that we would like to incorporate is contacting NASA. When we say in the future, we really talking into the future, like the next 100 years. When we use up all the resources in the Earth, we will need to move so that we can sustain our species. We won't be able to have electricity or farms so there is no real way to have food or produce to survive. We want to incorporate composting into life on Mars so that we can grow crops and produce and continue our normal lifestyle.

Uploaded Files:

- [View] **Meeting with the Mayor of the Village of Lisle** (By: Advisor, 02/20/2017, .pdf)

  Discussions with the Mayor on City-wide composting. Suggestions from the Mayor on next steps and outreach, and possible partners.
- [View] **Presentation to the Mayor of Lisle** (By: Advisor, 02/20/2017, .pdf)

  "Making Lisle Greener Than It Already Is" A presentation to the Mayor of Lisle Mr. Joe Broda asking for space in the City yards to run a compost heat recovery experiment

Mission Verification

(1) Does your Mission Folder project involve vertebrate testing, defined as animals with backbones and spinal columns (which include humans)? If yes, team must complete and attach an IRB approval form.

No

(2) Did your team use a survey for any part of your project? If yes, team must complete and attach a survey approval form.

No

(3) You will need to include an abstract of 250 words or less. As part of the abstract you will need to describe your project and explain how you used STEM (Science, Technology, Engineering and Mathematics) to improve your community

Team GreenHouseGals observed a web of problems in our community: increasing use of non-renewable fossil fuels, environmental risks stemming from extraction, excess fertilizer runoff and excessive waste diverted to landfills.

We explored composting for its potential to solve multiple problems. It nourishes soil naturally, keeps waste from landfills, saves homeowners costs on garbage, stickers and artificial fertilizers.

Most importantly, compost creates heat!!! We hypothesized that heat from compost can be successfully extracted by simple methods and would be a great renewable alternate energy source available to composters.

We built compost piles and monitored their ability to survive and produce heat through cold winter days. We designed multiple experiments to understand the efficiency with which heat could be extracted from a source. We studied heat transfer under controlled conditions and researched inexpensive piping choices for their conductive efficiency.

Our results verified that compost heat could be transferred rapidly with 3/8" PEX pipes, a simple pump, and water for heat exchange, even considering the heterogeneous natural state of compost.

To verify our hypothesis, met with large-scale composters. From Green Valley Landfill, we learned that large waste piles create significant heat (definitely an opportunity!!). From North Central College, we learned about other local large scale compost managers.

Benedictine University in Lisle invited us to participate in their Sustainable Saturday program and distribute our newsletter 'TRASH TALK' and encouraged us to pursue an F-SCRAP grant from the State of Illinois to convert Kennedy to a middle school that composts.

Tour of the Green Valley Landfill

Date: Jan 30th, 2017

In our compost research, we decided that we could learn a lot by visiting a closed landfill and seeing how they do things and how landfills work. Some major things we learned were how many risks that landfills carry. We learned about subsurface oxidation, aquifer contamination, explosion risks, and more.

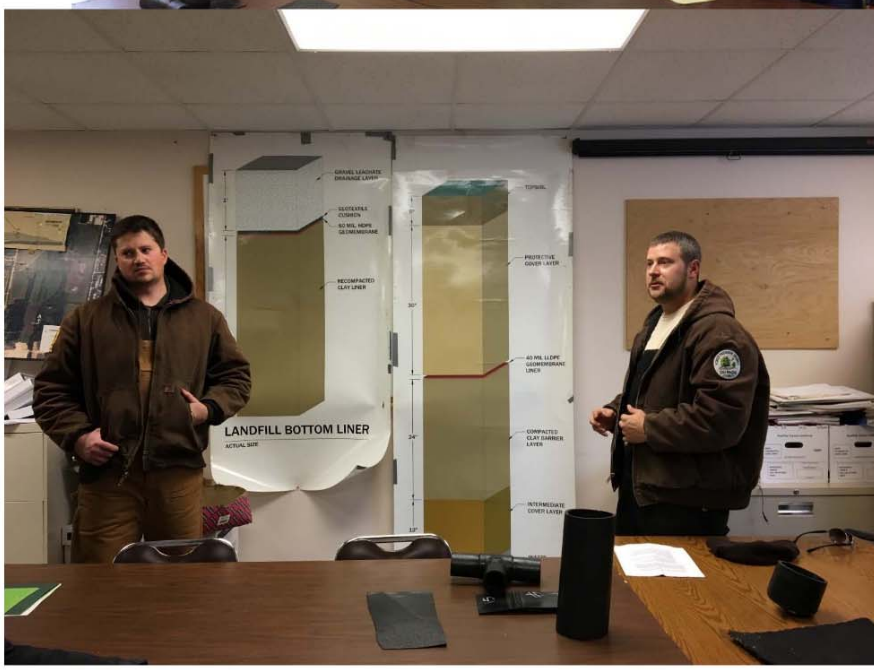
We were able to connect this to composting because if people compost, this can reduce the amount of waste accumulated in landfills, therefore also reducing of these risks. Failed landfills could hurt the environment by putting chemicals into the aquifers. Not only does this hurt the environment, but this can also hurt the people who are drinking this water.

We learned that compost really helps because all of the kitchen and yard waste going to landfills will be diverted and used in the compost instead. A landfill's secondary purpose is to harvest methane from anaerobic decomposition and burn it to create electricity. While this is somewhat beneficial, the landfill also has a very delicate system, which if broken can lead to disastrous effects.

When we visited, a vaccum pipe broke- one that sucked all the methane gas from the landfill into the generators. If not treated properly or having misplaced pipes or bad management, there could be oxygen that gets in and completes the fire triangle. This could start a dangerous fire inside the landfill and could be very unsafe.

Summary: The tour taught us that there is significant heat inside of a landfill. We were excited to hear this, as our experiment was considering the ability to harvest waste heat from composting organic matter.

Landfill construction is costly, trucking waste further and further away from cities is costly and the risks are significant.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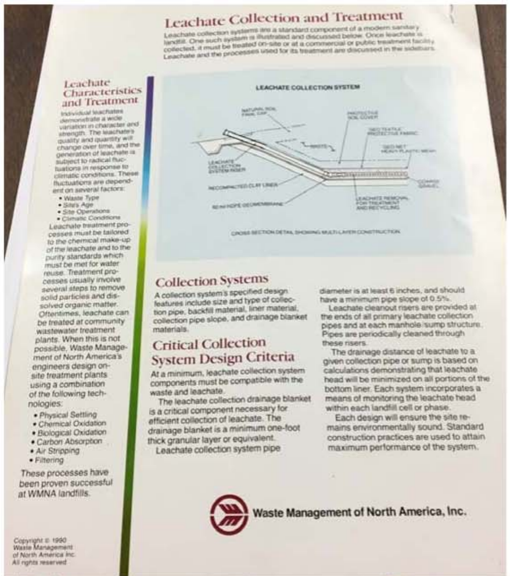


Leachate Collection and Treatment

Leachate collection systems are a standard component of a modern sanitary landfill. One such system is illustrated and discussed below. Once leachate is collected, it must be treated on-site or at a commercial or public treatment facility. Leachate and the processes used for its treatment are discussed in the sidebars.

Leachate Characteristics and Treatment

Individual leachates demonstrate a wide variation in character and strength. The leachate's quality and quantity will change over time, and the generation of leachate is subject to radical fluctuations in response to climatic conditions. These fluctuations are dependent on several factors:

- Waste Type
- Site's Age
- Site Operations
- Climatic Conditions

Leachate treatment processes must be tailored to the chemical make-up of the leachate and to the purity standards which must be met for water reuse. Treatment processes usually involve several steps to remove solid particles and dissolved organic matter.

Oftentimes, leachate can be treated at community wastewater treatment plants. When this is not possible, Waste Management of North America's engineers design on-site treatment plants using a combination of the following technologies:

- Physical Settling
- Chemical Oxidation
- Biological Oxidation
- Carbon Absorption
- Air Stripping
- Filtering

These processes have been proven successful at WMNA landfills.

Collection Systems

A collection system's specified design features include size and type of collection pipe, backfill material, liner material, collection pipe slope, and drainage blanket materials.

Critical Collection System Design Criteria

At a minimum, leachate collection system components must be compatible with the waste and leachate.

The leachate collection drainage blanket is a critical component necessary for efficient collection of leachate. The drainage blanket is a minimum one-foot thick granular layer or equivalent.

Leachate collection system pipe diameter is at least 6 inches, and should have a minimum pipe slope of 0.5%.

Leachate cleanout risers are provided at the ends of all primary leachate collection pipes and at each manhole/sump structure. Pipes are periodically cleaned through these risers.

The drainage distance of leachate to a given collection pipe or sump is based on calculations demonstrating that leachate head will be minimized on all portions of the bottom liner. Each system incorporates a means of monitoring the leachate head within each landfill cell or phase.

Each design will ensure the site remains environmentally sound. Standard construction practices are used to attain maximum performance of the system.

Waste Management of North America, Inc.

North Central College (NCC)

Date Feb 2nd, 2017
Our team did some research and found out that North Central College does composting. We wanted to learn more about how they compost and visited the campus to find out.

North Central's sustainability coordinator Ms. Brittany Drummond, spent an afternoon with us, showed us their composting management and process.

NCC collects food scraps that the students don't want and use it for compost. They have special bins and bags just for compost. NCC also has their own garden using compost to grow vegetables. We learned a lot about things that they do to compost and would apply and use this information in our composting research and experiments. Normally dairy and meat cannot be composted because of the fat and pests, but in NCC, but Brittany told us that they have a way that they can compost meat and dairy.

NCC diverts 29% of their waste now from landfills. North Central's goal by 2020 is to divert 40% of their waste to landfills. In January, 2017, North Central got rid of styrofoam to be more earth friendly. We took away a lot from our NCC tour. We learned a lot more about composting and how schools do it from this tour.

Summary: We learned that Brittany and NCC do not manage their own compost but instead have a local Nursery and Green Composter come and truck it away. Garden Prairie Organics was their name. North Central College was very supportive of efforts to encourage more composting in the local area.

Experiment #1

HYPOTHESIS:

We believe that a simple backyard compost pile is capable of producing heat and sustaining bacterial decomposition even during the cold winter months.

INDEPENDENT AND DEPENDENT VARIABLES, CONTROL GROUP AND CONSTANTS:

As composting is part of a natural biological process, there are a number of independent variables:

- Size of pile: 6 yard bags worth of fall leaves, weekly kitchen scraps.
- Shape of Pile 1: Flat heap, covered with a loose tarp.
- Shape of Pile 2: Constructed compost bin with wood stakes and galvanized chicken wire wrap.

The dependant variables:
- Temperature of the Pile: See graph of temperatures measured across one week, measured in the middle of the pile.

Control Group: None. This was the first experiment to determine heat production in winter.

Constants:
- Time of year/weather conditions when pile is built: Built on November 13, fall season
- Location (Exposure of Pile to direct sunlight): south facing backyard, direct sunlight
- Type of composting (aerobic vs. anaerobic): aerobic compost pile, watered regularly
- Material in pile: 6 bags of leaves, weekly food scraps
- Moisture of pile: Watered regularly, about once a week
- Position of pile: In path of sunlight
- Turning rate: Once a week

COULD HYPOTHESIS BE TESTED AND COULD BE PROVEN FALSE BY TESTING?

When we first built our two compost piles, we wanted to see if compost had the potential to rise to high temperatures. We tested this experiment by monitoring our two compost piles, checking the temperature regularly to see how the temperature changed. We knew that this could be proven false because we weren't aware yet if the compost pile would be able to sustain itself in the cold of winter and even give enough heat to act as a substitute source of energy.

MATERIALS

- Wood
- Nails
- Tarpaulin
- Chicken Wire
- Thermometer
    - First measurements: Manual Electronic Probe Thermometer
    - Remaining measurements: Wireless Thermometer with Remote Sensor, buried in middle of pile in a ziplock bag.
- 180 Gal (6 yard bags) Leaves, approx 12 Gal food scraps, 15 Gal wood mulch
- Bricks and large sticks to hold down the tarp covering the pile
- Water (1 Gal per week added when turning)

EXPERIMENTAL PROCESS AND METHODOLOGY

Safety Precautions:

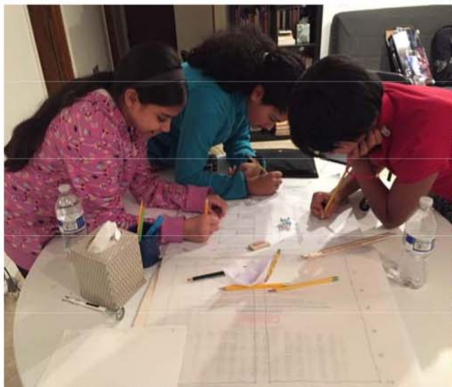
- Wearing close-toed boots for safety against splinters
- One person at a time sawed and drilled the wood
- The team in the garage working with wood wore safety goggles
- Adults helped train and oversee us with all electronic and manual tools
- We all wore rubber gloves to protect our hands

Created Two Small-scale Piles

Pile #1- Flat Pile:

1. Collect 6; 30 gallon bags of leaves, yard wastes, food waste

2. Arrange into mound shape and moisten with water
3. Cover with tarpaulin and weigh down with bricks and large sticks
4. Periodically turn the pile and monitor temperatures of pile.




Pile#2- Built Pile:

1. Collected 2 bags of leaves (yard waste)
2. Bought (6) Nos. of 2x4x8’ long wood
3. We sawed wood into 12 Nos. of 4’ long sticks
4. Later, we predrilled holes and used wood screws to connect the pieces together into two frames and used 4 pieces as vertical connectors.
5. Once the compost bin was in the cube shape, we wrapped the frame with chicken wire
6. Then we added the collected organic material and moistened it
7. The pile was covered with a tarp to keep snow out in sub-zero temperatures.
8. Temperatures were recorded.

DATA COLLECTION

Monitoring Compost:

Two of us kept separate compost piles in our backyards (one flat, one built-up). We would record the temperature of the piles on a regular basis to observe the heat compost gives and how it can relate to our heat exchange experiments. Once a week, we would look at our compost pile, add yard waste and kitchen scraps, and turn the pile over. We would have to be in charge of our own piles, watering it, and giving it the proper care to become aerobic piles.

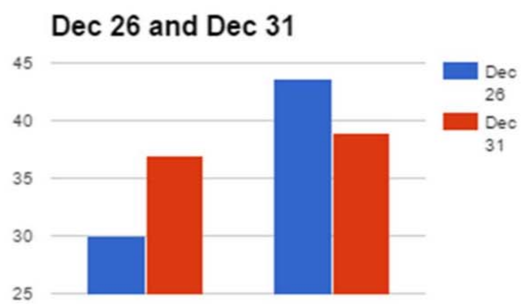
Whenever we opened the tarp to check the temperature of the pile, we were afraid that we would lose some heat. So, we put a sensor in the center of the pile and purchased a wireless thermometer so that we could check the temperature of the pile without disturbing the microbes.

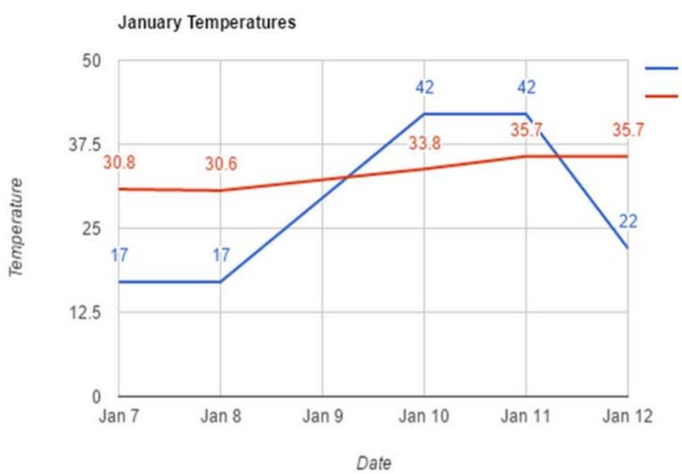

WIRELESS
THERMOMETER
MIN/MAX
Temperature
68.7°F
50.3°F
LA CROSSE
TECHNOLOGY
La Crosse
6.5"
THERMOMETER
Key Hider · Mercury-free
La Crosse
120
100
80
60
40
20
0
-20
-40
°F


1:29 20
INDOOR
67.1 °F
OUTDOOR
14.8 °F
LA CROSSE®
TECHNOLOGY

RESULTS

Red: Compost, Blue: Outside





ANALYSIS:

Even though the outside temperature was sub zero, the compost temperature climbed steadily upwards and stayed at elevated temperatures for long periods of time. Our data supports the hypothesis because the compost pile generated heat, and was not affected by the outside temperature.

This proves that as long as there is the correct carbon:nitrogen ratio and a good amount of water and oxygen, a compost pile in winter is able to generate its own heat.

SOURCES OF ERROR:

We felt we may have needed more consistent temperature readings over a longer period.
We felt a plastic tarp could limit the pile's access to oxygen.

CONCLUSION:

We confirmed that compost creates heat and is not shut down completely by other variables such as low outside temperatures. If we wanted to retest or further test our hypothesis, we would definitely take more regular readings so that we would have more of a consistent graph.
The data that we collected was important for our experiment because we saw how much heat a small backyard compost pile could produce. We felt that this confirmed that if the pile were larger it could produce a larger amount of heat more consistently.

An idea for future experiments is changing the tarp to a GORE-TEX tarp fabric. This is a more breathable tarp that will allow more access to the oxygen to the compost pile. Also we should put wireless thermometers in more spots within the pile. This will make us aware about how consistent the temperature is throughout the mass of the pile.

IMPORTANCE OF TUBING CHOICE

If the heat from the compost pile needs to be extracted to be usable, we need tubing materials that can be placed inside the pile. Water can then be sent into the pile using this tubing to extract the heat from the outflow.

SELECTION CRITERIA:

- Thermal conductivity - good for water heat exchange.
- Flexibility - The pipe should be easily wound around and flexible for coils inside the compost.
- Wall thickness - The wall thickness of different readily available tubing needs to be accounted for. The smallest wall thickness is best but puncture resistance is important.
- Cost - Cost effectiveness is important. The compost piles are outside and costly metal materials like copper could be targets for thieves.

PIPE OPTIONS READILY AVAILABLE IN THE MARKET:

1. Latex tubing ⅜" O.D. ¼" I.D. This pipe has a maximum temperature of 180 degrees. This is good for our compost because our compost will probably not get up to a temperature that high. Also, latex tubing is less puncture resistant because of the rubber wall but it is more flexible.
2. Clear Vinyl Tubing 3/16" O.D. ⅛" I.D. This pipe's temperature resistance is only 70 degrees Fahrenheit but it is still good because of the the thick, puncture resistant wall. Unfortunately, this could mean that it is not a conductive pipe.
3. Polyethylene Tubing ¼"O.D. 17/100" I.D. This pipe also only has 70 degrees Fahrenheit. The materials are non toxic & the pipe can be used to carry drinking water.
4. PEX ½ inch diameter 20ft pipe (Lowes) - https://www.lowes.com/pd/Apollo-1-2-in-x-20-ft-160-PSI-PEX-Pipe/3659976 . This pipe is heat conductive as well as very inexpensive (only 2$!) as well a durable alternative to other, flimsier pipes.

A paper by John patterson and team (**REF # 1**) compared various materials in heat transfer in a solar collector. This experiment and its findings were very applicable to our set up. It explained that metals extremely outperformed plastics in the area of heat conductivity. In the case of metal pipes, the thermal conductivity (in Watts per meters Kelvin) was 100-400 times better in the case of heat conductivity.

Thermal Conductivity of Tubing Materials

Piping	Material	W/mK
Steel	Carbon Steel	54
Copper	Copper	401
PEX	Cross-linked High-density Polyethylene	0.51
CPVC	Chlorinated Polyvinyl Chloride	0.14
PE	Polyethylene	0.38
PVC	Polyvinyl Chloride	0.19

FINAL CHOICE

We visited hardware stores and compared costs, lengths, wall-thicknesses of available choices. We created a table to help us determine the optimal choice.

Material	Conductivity in W/mK	Flexibility	Cost	Wall thickness = (OD-ID)/2	Final Choice
PVC PolyVinyl Chloride (Clear Vinyl Tubing)	0.19	High	$0.17 per linear ft.	1/32”	
PE Poly Ethylene	0.38	High	$0.17 per linear ft.	1/25”	
PEX - Cross linked PolyEthylene	0.51	Medium	?	1/16”	FINAL
Copper	401	High	Very high	1/40”	

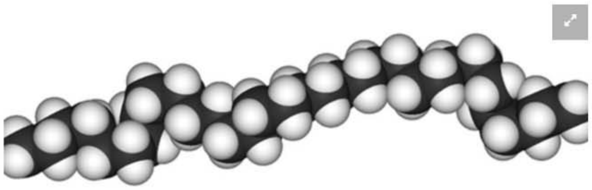
We find that PEX tubing is the best optimal choice: durable but flexible, most heat conductive and cost effective, less vulnerable, harder shell is resistance to punctures, best for use in an early pilot project.

LOOKING TO THE FUTURE

Another article (**REF #2**) in Popular Science shows that in the future, there could be plastic pipes that would outdo metals in heat conductivity but they’re not readily available as of today.

Researchers at MIT were manipulating the molecular structure of polyethylene fibers to allow them to conduct heat better.

This Popular Science article explains that a research team at MIT has altered the molecular structure of polyethylene fibers. They drew out the fibers from a solution, making the molecules all face one way. This allowed heat to be conducted much better through the pipe wall. Either the heat can go out of the pipe or it can get in.



Polyethylene

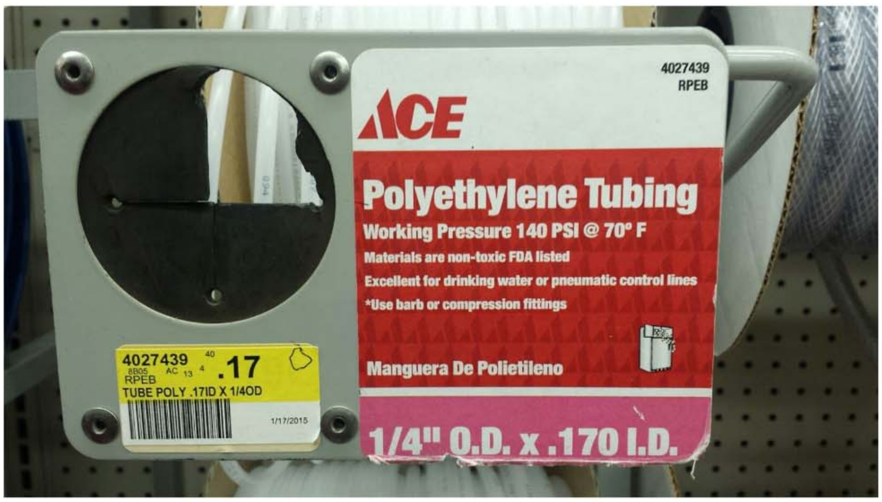
Chains of polyethylene molecules like the one above tend to arrange themselves chaotically, but by figuring out how to make the molecules line up straight, MIT researchers have created a highly conductive new polymer that conducts heat in only one direction.

SOURCES

REF #1: John E. Patterson□Ph.d. And Ronald J. Miers□Ph.d. "The Thermal Conductivity of Common Tubing Materials Applied in a Solar Water Heater Collector." The Thermal Conductivity of Common Tubing Materials Applied in a Solar Water Heater (n.d.): n. pag. Web. 29 Jan. 2017. http://ascpro0.ascweb.org/archives/cd/2010/paper/CPRT192002010.pdf Collector

REF #2: Dillow□Clay. "New Plastic Conducts Heat Better Than Metals□But Only in One Direction." Popular Science. N.p.□Mar. 2010. Web. 29 Jan. 20 http://www.popsci.com/science/article/2010-03/new-polymer-conducts-better-metals-only-one-direction17.


4039061
RVDC
ACE
Clear Vinyl Tubing
Working Pressure 55 PSI @ 70° F
Use for drain lines or protective cover
Do not use on ice makers
*Use hose barb fittings with clamp
Manguera De Vinilo Transparente
3/16" O.D. x 1/8" I.D.
4039061
RVDC
1/17/2015

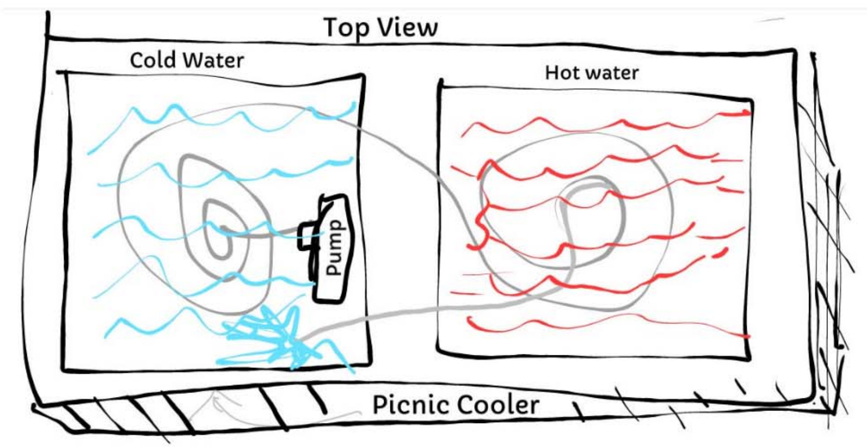

4027439
RPEB
ACE
Polyethylene Tubing
Working Pressure 140 PSI @ 70° F
Materials are non-toxic FDA listed
Excellent for drinking water or pneumatic control lines
*Use barb or compression fittings
Manguera De Polietileno
1/4" O.D. x .170 I.D.
4027439
RPEB
.17
TUBE POLY .17ID X 1/4OD
1/17/2015

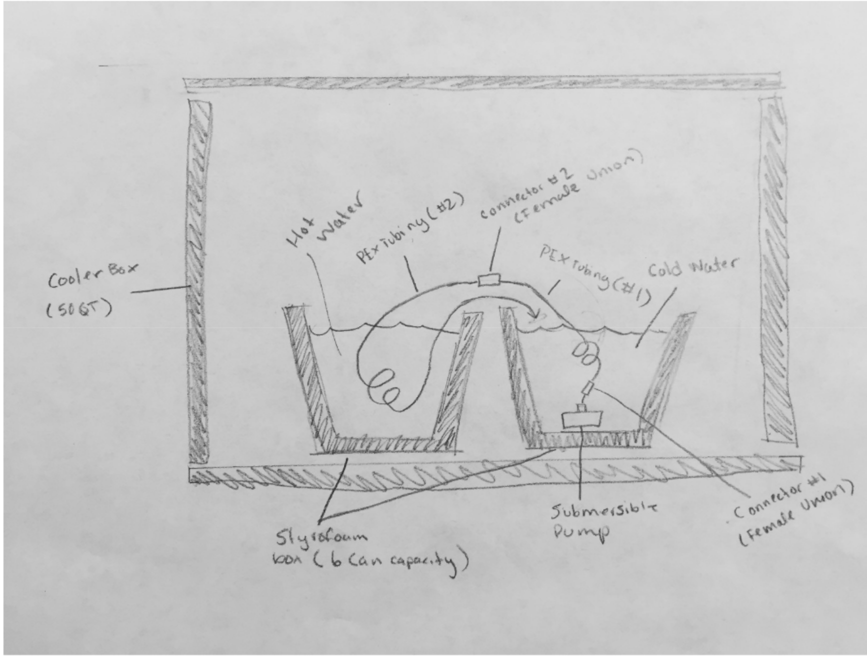
Experiment #2

Hypothesis:

We believe that the heat from a compost pile can be harvested easily and efficiently. We hypothesize that with the right tubing choice and a low flow pump, and water, it would be possible to create and measure the transfer of heat from a hot SOURCE (e.g., compost) to a colder SINK (e.g, green house shed, garage or warehouse concrete slab etc.).

Experimental Design





INDEPENDENT AND DEPENDENT VARIABLES

Independent Variable:

- Starting temperature of hot and cold water
  - Hot: 127°
  - Cold: 42°

*Note: * We chose these temperatures to keep our water at, because we felt that they best simulated the temperature inside a compost pile (Hot temp) and a pavement floor in winter (Cold temp)*

Dependent Variable:

- Equilibrium temperature
- Time till equilibrium

CAN EXPERIMENT PROVE HYPOTHESIS TRUE OR FALSE?

We wanted to set up an experiment to demonstrate how the heat that compost gave off could be taken and transported from a source to a sink. We needed to choose the most appropriate, commercially available plastic tubing for the heat exchange tubing. We looked at different tubing that were cost effective and had good heat conductivity.

We put hot and cold water in two bins side by side, hot water representing hot compost, and cold water representing a slab or a shed and ran PEX pipes through the two bins. The cold water went through the pipes, with the pipe absorbing the heat through the pipe wall and transferring the heat to the cold water bin. We also acquired a low cost, low flow, submersible pump so that the water would constantly be moving. We kept measurements on time and temperature so that we could look at the results in a graph after the experiment was done.

Our hypothesis for this experiment could have been proven wrong if the heat exchange took an inordinately long time to transfer heat from hot to cold bins.

MATERIALS:

- 2 Styrofoam boxes (Ace Hardware)
- Submersible water pump (Amazon),
- Tubing - PEX tubing, ⅜" OD, ¼" ID, 5' long (Lowe's)
- 3/8" OD 12" long pieces of PVC for flexible connectors to pump
- 2 Nos., 3/8" OD to 3/8" OD, push connector
- Thermometer (Ace Hardware)
- 148 and 37 degree water
- Timer (SAMSUNG)
- Picnic cooler (IGLOO)

FINAL CHOICE OF TUBING FOR HEAT EXCHANGE EXPERIMENT

We visited hardware stores and compared costs, lengths, wall-thicknesses of available choices. We researched the conductivity of various materials. We created a table to help us determine the optimal choice.

Thermal Conductivity of Tubing Materials

Piping	Material	W/mK
Steel	Carbon Steel	54
Copper	Copper	401
PEX	Cross-linked High-density Polyethylene	0.51
CPVC	Chlorinated Polyvinyl Chloride	0.14
PE	Polyethylene	0.38
PVC	Polyvinyl Chloride	0.19

Material	Conductivity in W/mK	Flexibility	Cost	Wall thickness = (OD-ID)/2	Other notes	Final Choice
PVC PolyVinyl Chloride (Clear Vinyl Tubing)	0.19	High	$0.17 per linear ft.	1/32”	Too soft, no puncture resistance	
PE Polyethylene	0.38	High	$0.17 per linear ft.	1/25”	Too soft, no puncture resistance	
PEX - Cross linked PolyEthylene	0.51	Medium	$0.50 per linear ft.	1/16”	180 deg F, good high range for temperature	FINAL
Copper	401	Low when compared to plastics	$1.50 to $2.00 per LF	1/40”	High loss/burglary risk	

We find that PEX tubing is the best optimal choice: durable but flexible, most heat conductive and cost effective, less vulnerable, harder shell is resistance to punctures, best for use in an early pilot project.

CONTROL GROUP & CONSTANTS:

Control Group:

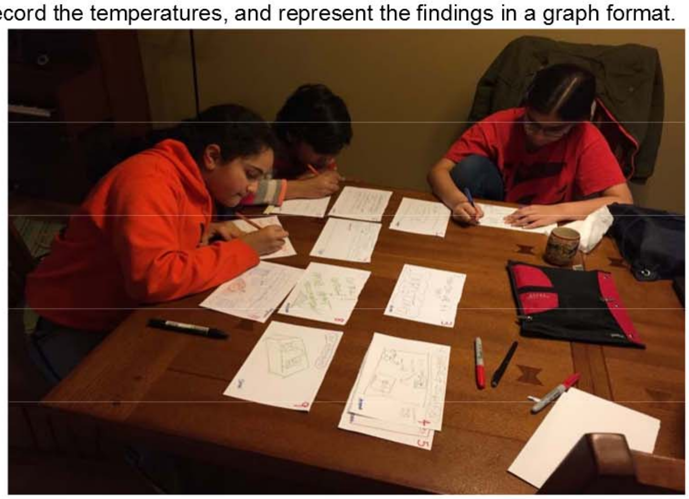
- None

Constants:

- Conductivity of pipe
- Flow rate of pump
- Volume of water

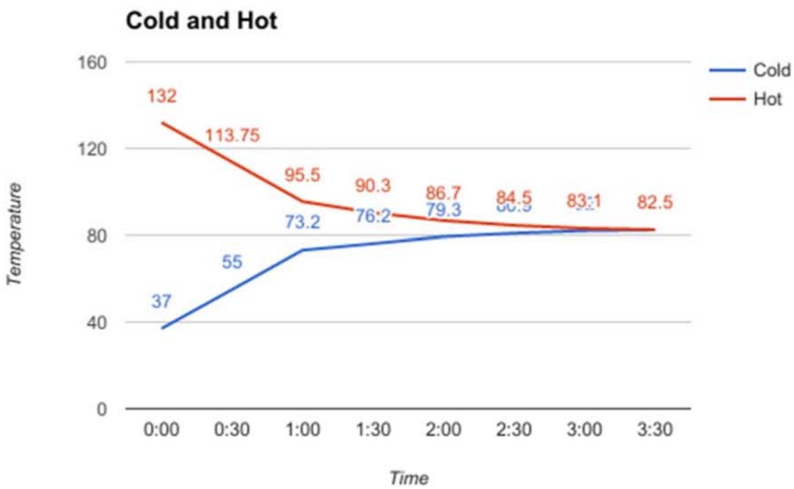
METHODOLOGY

1. Place two styrofoam boxes side by side inside a picnic cooler so heat is not lost to the environment.
2. Coil two PEX pipes into 3 loops and secure them with wires and duct tape to have as much surface area of the pipe covered as possible with water, and fill the box entirely.
3. Place a submersible pump inside one box, and connect it to the coiled PEX pipes. The pump would circulate the cold water through the pipes, into to the warm water, and empty the slightly heated water into the same container, repetitively. This would gradually make the temperature change because of the heat exchange and conductivity of the pipe.
4. Monitor the temperatures of the cold and hot water, every 30 minutes, utilizing a timer and thermometer.
5. Record the temperatures, and represent the findings in a graph format.




DIGITAL THERMOMETER
HOLD
ON/OFF
°C/°F

RESULTS



ANALYSIS:

Based on the results, we found that the average rate of heat exchange was approximately 1 per 7.5 minutes.

In the first 2 hours, the cold SOURCE dropped in temperature from 132 to 86.7 deg F, a total drop of 45.3 deg F. In the same timeframe, the cold SINK rose in temperature from 37 to 79.3, a rise of 42.3 deg F. The efficiency of heat transfer in the first two hours was 1 deg F (average) every 2.7 minutes.

In other words, the heat transfer was accelerated when the temperature difference between the SOURCE and SINK was high. As the temperature reached equilibrium, the rate of heat exchange slowed.

Our data supports the hypothesis because we were able to successfully demonstrate heat transfer, and its efficiency over time and temperature differences.

ERRORS:

Some errors that we can avoid for an experiment in the future is the number of thermometers and the size of the thermometers. We used one thermometer for both the cold and hot water, but it would have been much more efficient if we had used two thermometers, one for each bin. We should also make sure that the thermometers are smaller because then we can leave them in the bins and close the lid of the picnic cooler, so less heat escapes. Another error that we can rectify in the future is the length of pipe we purchase. We didn't get that much pipe and therefore, we didn't have as many coils of pipe going through the water. This could result in the heat taking longer to transfer because of less surface area. We also did not have a control experiment. If we were to run this experiment again, we would keep two bins of the same temperature, but not run the setup to monitor the natural heat gain and loss to surroundings.

CONCLUSION:

Based on our experiments and results, we can see that our experiment actually did **prove our hypothesis TRUE**. We concluded that the heat exchange was much faster & more effective in the initial stages when the difference between the source & sink was high. In the real world this would happen with large compost piles transferring heat to cold elements like buildings and sheds

We saw that in the beginning stages, the ratio was about 1°F per minute. After about 1-2 hours had passed, the rate became about 1°F per 10 minutes.

After only 2.5 hours, both of the tubs were at near equilibrium, settling at about 82 degrees. We hypothesized it would take 7-8 hours for it to happen. In reality, it only took 3. In a nutshell, it happened, and it happened fast. The data that we collected was very useful because now we know that we have all the right materials & we can successfully use heat exchange for claiming the heat from compost.

NEXT STEPS:

We determined that water was the best medium because it comes in complete contact with the outside of the pipe at all times and it has a high conductivity. We realized that our target material of compost would not be as good, because water has convection currents, and spreads the heat, yet we wanted to get closer fulfilling our plan, so we decided to run experiment three with cold water and compost instead of hot water.

Experiment #3

HYPOTHESES:

Specific Hypothesis: We hypothesise that replacing the water in the source bin with compost will have a lower heat exchange efficiency, taking a longer time to reach equilibrium.

Specific Hypothesis: We hypothesize that the temperatures within the compost in the source bin will not be consistent, because it does not have convection currents.

INDEPENDENT AND DEPENDENT VARIABLES:

Independent Variables:
- Compost: 144.5°F
- Cold: 48°F

Dependent Variables:
- Equilibrium temperature of compost and water,
- Time till equilibrium temperature is reached.

CAN EXPERIMENT PROVE HYPOTHESIS TRUE OR FALSE?:

We replaced hot water with compost in this experiment, to be a more accurate simulation of real conditions. Our hypothesis is that we wanted to be able to harness heat from compost. We did this, and transferred the heat to cold water from the hot compost. We expected the temperature of the compost pile to be inconsistent in different areas because of the nature of compost. This experiment could have possibly proven our hypothesis wrong, if we found that the heat exchange using compost was completely slow and did not effectively exchange the heat from the compost to the cold water.

MATERIALS:

- 2 Styrofoam boxes (Ace Hardware)
- Submersible water pump (Amazon)
- Tubing - PEX tubing, ⅜” OD, ¼” ID, 5’ long (Lowe’s)
- 3/8” OD 12” long pieces of PVC for flexible connectors to pump
- Duct tape and Galvanized tie wires (for coiling pipe)
- Thermometer (Ace Hardware)
- 180 and 42 degree fahrenheit water
- Ice cubes
- Clock for time (Computer)
- Picnic cooler (IGLOO)
- Compost (from our own piles)
- Rubber Gloves
- Hand Fork
- 5 Gallon Pail

CONTROL GROUPS AND CONSTANTS:

Control Group:

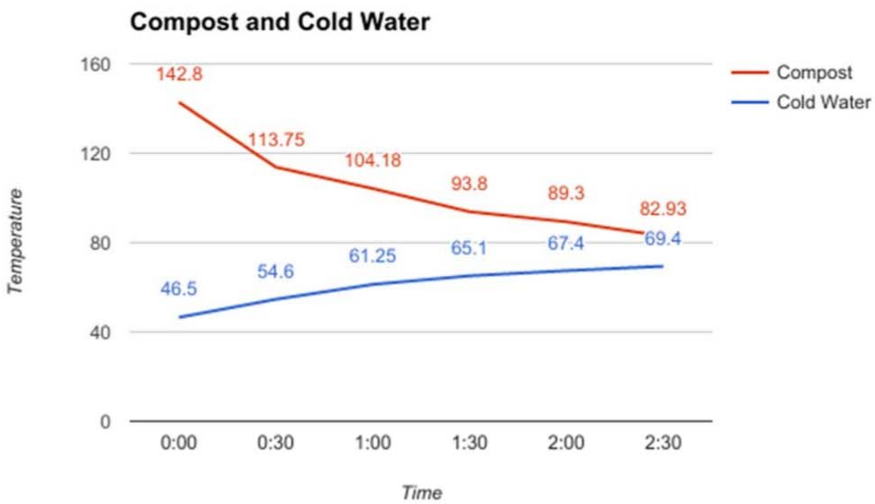
- Experiment #2 was the control group for Experiment 3, to compare findings against.

Constants:
- Conductivity of pipe
- Flow rate of pump
- Volume of styrofoam bin

METHODOLOGY:

1. Set up the pipes and buckets just like in experiment two.
2. Cool water to get to as close to 40° (see note in exp 2. control/variable) - Keep aside
3. Heat water on bunsen burner to 180° - keep aside
    a. Note: we had 50° compost, and we wanted ~130° material, so we excessively heated water 50° extra. (see also note in exp 2.)'
4. Lightly pack compost into bucket.
5. Pour cold water into the other bin at slightly less height
    a. This height difference is to account for the ice cubes and hot water.
6. Pour ice cubes into the cold water
7. Pour the hot water into the compost
    a. This is to exaggerate the temperature difference between the cold water & compost, and simulate the temperature in an active compost pile.
8. Record temperatures of both bins
9. In addition, record the temperature at all four corners of the compost bin to determine the consistency of heat within the heterogeneous compost material

RESULTS (GRAPH):



ANALYSIS:

From the data we collected, we realized that our hypotheses were indeed correct: the water-to-water transfer was more efficient than the compost-to-water, and the compost bucket had uneven temperatures in different areas.
We saw this when we measured the four corners of the compost, and saw that the temperatures were significantly different. We documented the average for sake of the graph.

The hot SOURCE dropped 53.5 deg F in two hours while the cold SINK gained only 22.9 deg F. We determined this may be because of the smaller quantity of actual water volume inside a heterogeneous compost mix.

ERROR/RETEST:

Some things we would add if we had to repeat the experiment would be to have a larger scale of experiment, choosing longer, more flexible pipe that would get around the bucket more consistently, and a setup that was more robust. If a more suitable pipe was unavailable, then we would have bought more of our current pipe so we would get more freedom with our pipe coils and placement in the buckets.

We would conduct the same experiment with different moisture levels in the compost to check efficiency for heat transfer.

CONCLUSION:

Based on this experiment's results, we learned that compost can successfully conduct and exchange heat at as high as 2.5°F per minute, yet our findings show that it no matter what, it can not transfer heat as well as water would, proving our hypothesis correct. The data we collected from our experiment was very useful, because now we know that it is possible to claim a significant amount of heat from our compost pile, and transfer it.

NEXT STEPS:

Our next steps for this experiment would be using a bigger pile. We would use a bigger pile so that we can get more heat out of it. We would cement pipes into an actual concrete slab that would model the floor of a shed or building that we could heat with the energy from our compost bin.

The Mayor’s Office,
Village of Lisle, Illinois

On Feb. 9th, 2017 we met with the Mayor; Mr. Joe Broda of Lisle, and learned a few things about politics. We found out that the city didn’t just pay Waste Management every time they came around but the town actually had a long standing contract with the waste hauler.

Lisle has been riding on this current contract for about 5-7 years but there are only 2 years left till a new one must be signed. This is a negative side effect for our project, because we can’t do it for the next 2 years because he has to sign a new one in 2019 so we have to wait for that time to come before we can implement that idea.

Also, if more and more people are making huge mountains of garbage every few years, all the landfills in our area will be filled. Then, the waste haulers will be forced to drive farther away from where they pick up the garbage. This means that the gas prices and vehicle fees will get higher as the landfills get farther from where we live. This also means that our garbage stickers will become more expensive because the prices that we have to pay for the waste hauler is also going up.

Then, we learned that if we were to implement this idea into our community, we would have to be cost efficient. Finding a cheap, inexpensive way to pick up the compost from people’s house was one of the most important parts. Space was also relevant; where would we put the compost?

Summary:

Mayor Broda gave us great suggestions.

Why not put an article into the Lisle Green Newsletter? It was read by about 21,000 people so it was quite a prominent magazine. If we published in there, we would definitely have some listeners that would hear out our pleas and start their own backyard composting.

The Mayor also indicated that the Morton Arboretum in Lisle managed its own compost, and was a willing receiver of yard waste, tree and brush clippings and fall leaf collections from the Village of Lisle

We went away understanding that the Arboretum was a great potential partner for the compost heat harvesting idea.


NAPY

Making Lisle Greener Than It Already Is

Divya Lidder,
Sruthi Kotlo &
Anjana Ramachandran

The Greenhouse Gals

Garbage sticker cost (~$3 + bags)

Excess garbage in landfills

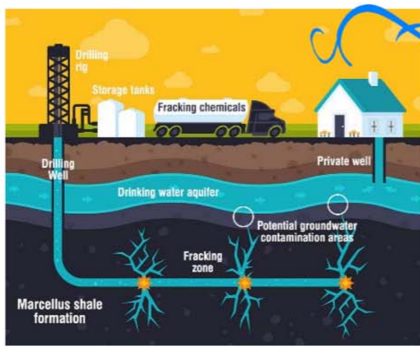
- Landfills have many risks too
- Needs lot of land, Subsurface oxidation
- Aquifer Contamination, Eye-sore

Water contamination from artificial fertilizers runoff

- Marine life negatively affected, Algae buildup
- Like Steroids

Increased fossil fuel use

- Pollution, Green-house Gases



Community Problems

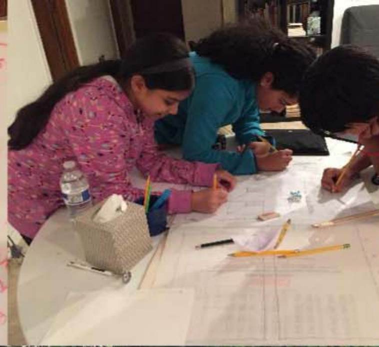
How can we fix this?

Composting!

Compost Waste Heat Reclamation!

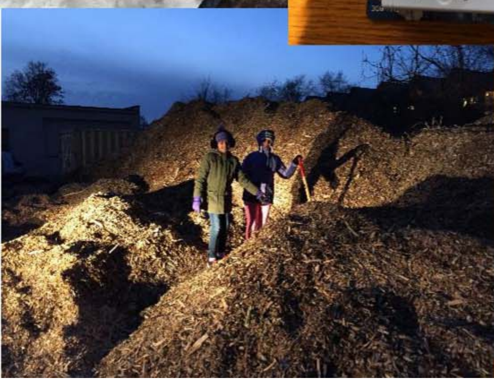
EXTRA! EXTRA!

- Lots of waste heat after thermophilic cycle is completed
- Harvest the heat energy
- Explore Heat Exchangers
- Even less complicated than geothermal
- Reduce or offset fossil fuel use.


Using compost to help the poor
COMPOST
Informing people
Heating water





WIRELESS THERMOMETER
6.5" THERMOMETER
La Crosse
120
100
80
60
40
20
0
-20
-40
°F




4027439
RPEB
ACE
Polyethylene Tubing
Working Pressure 140 PSI @ 70° F
Materials are non-toxic FDA listed
Excellent for drinking water or pneumatic control lines
*Use barb or compression fittings
Manguera De Polietileno
.17
POLY .17ID X 1/4OD
1/4" O.D. x .170 I.D.

Our Experiments

Potential of Compost Piles to generate heat through fall and winter

Sizes and Shapes of Piles

Three different variations of volume and shape of piles

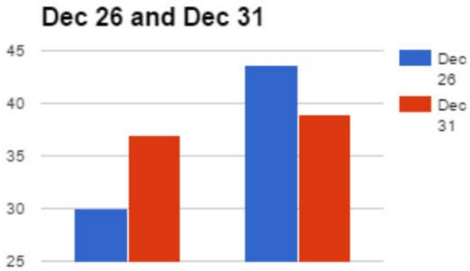
Harvesting the heat

Running water through PEX pipes buried or set within the compost

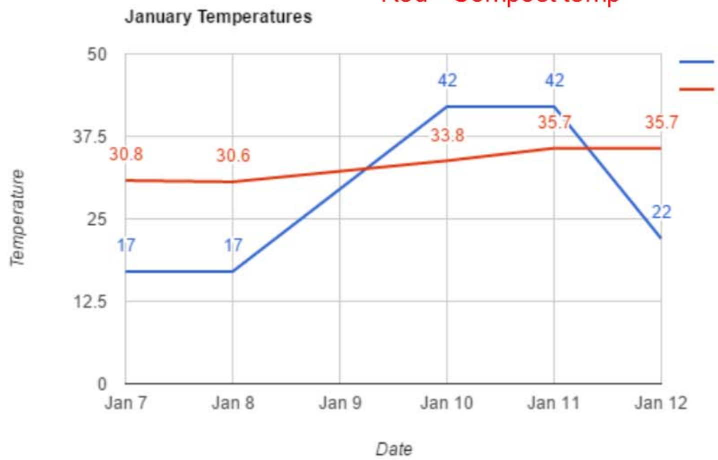
Determining the best tubing choice

Measuring heat exchange and efficiency

Compost Temperature Graph



LEGEND
Blue - Outside Temp.
Red - Compost temp



Our Experiment

IMPORTANCE OF TUBING CHOICE

If the heat from the compost pile needs to be extracted to be usable, we need tubing materials that can be placed inside the pile. Water can then be sent into the pile using this tubing to extract the heat from the outflow.

SELECTION CRITERIA:

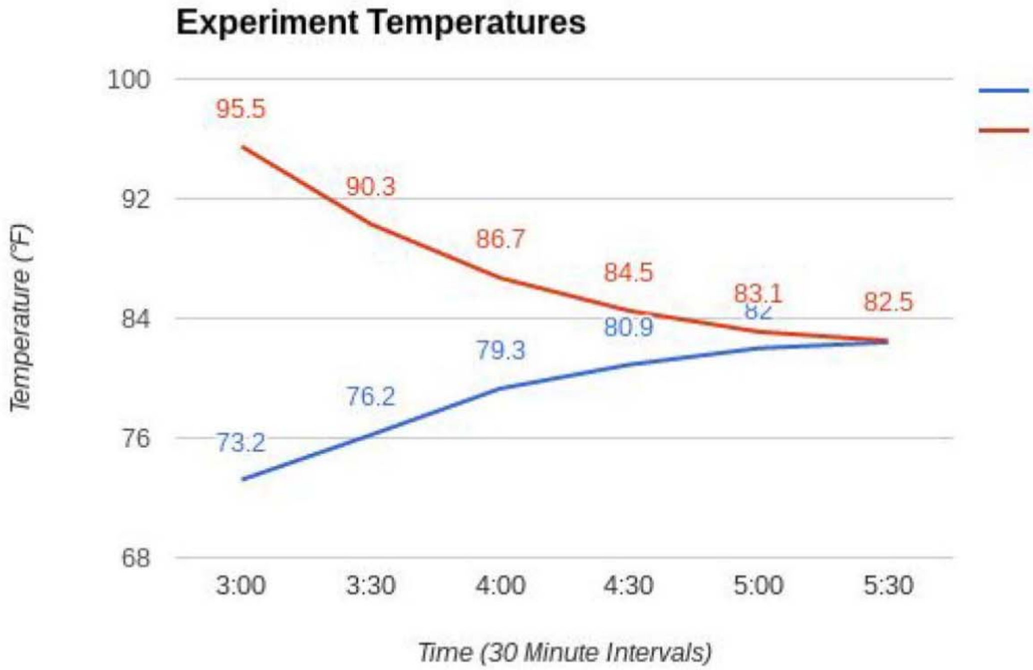
- Thermal conductivity - good for water heat exchange.
- Flexibility - The pipe should be easily wound around and flexible for coils inside the compost.
- Wall thickness - The wall thickness of different readily available tubing needs to be accounted for. The smallest wall thickness is best but puncture resistance is important.
- Cost - Cost effectiveness is important. The compost piles are outside and costly metal materials like copper could be targets for thieves.

Thermal Conductivity of Tubing Materials

Piping	Material	W/mK
Steel	Carbon Steel	54
Copper	Copper	401
PEX	Cross-linked High-density Polyethylene	0.51
CPVC	Chlorinated Polyvinyl Chloride	0.14
PE	Polyethylene	0.38
PVC	Polyvinyl Chloride	0.19

Material	Conductivity in W/mK	Flexibility	Cost	Wall thickness = (OD-ID)/2	Final Choice
PVC PolyVinyl Chloride (Clear Vinyl Tubing)	0.19	High	$0.17 per linear ft.	1/32”	
PE Poly Ethylene	0.38	High	$0.17 per linear ft.	1/25”	
PEX - Cross linked PolyEthylene	0.51	Medium	?	1/16”	FINAL
Copper	401	High	Very high	1/40”	

Results Blue: Cold Water | Red: Hot Water



Composting on a Large Scale: Benefits

Reducing uncontrolled algae growth in the Mississippi, Gulf of Mexico

Protecting water resources, marine life

Reduce runoff of industrial soil conditioner usage

Reducing organic food scraps and yard waste: 14.3% of the nation’s wastebasket

Successful Examples of Large Scale Composting

Some large cities: Seattle, San Francisco

Some in the neighborhood: Oak Park, Naperville, Wheaton

DuPage County, Kane County, Cook County, Lake County

Where You Come In!

Help us out with large scale composting!!!

Inspiration from Cedar Grove Composting

Can we do something similar here?

Visited with North Central College to understand large-scale composting

Saw Lisle Public Works Yard

Would you consider a Two year Plan?

"Compost stickers" prices

Why this works out

MAYOR

- Less money used for renting landfill space
- Less transportation fee for taking trash to a landfill

CITIZENS

- Half of their garbage is taken away for cheaper amounts.

VILLAGE

- Reducing carbon footprint
- Increasing water quality in lisle waterways

Possible Pilot Project With the Village of Lisle

City Scale composting: Benefits of waste reduction

Possibility of creating 20x30 yard compost pile at Lisle public works yard

Summer 2017 pilot project

Involves providing residents with curbside compost pickup bin

Year 1 benefits: Fresh Fertilizer, free microbe-rich soil for village residents

Year 2 benefits: Heat reclamation for use in Village GreenHouse

Potential Partners In the Lisle/ Naperville Area

North Central campus composting efforts ✓

Benedictine University Sustainability Efforts ✓

Education outreach in High schools and middle schools

NORTH CENTRAL COLLEGE
NAPERVILLE, ILLINOIS
Founded 1861

The Next Steps

- Joining and helping with Sustainable Saturday
- Spread the word about benefits of Composting
- Contacting SCARCE to help with Kennedy Jr High education
- How about SD 203?
- Join hands with Benedictine and NCC
- Contact “Upcycle Inc. for Lisle Municipal discounts on composters
- Contact Garden Prairie Organics

Trash Talk

Why Compost?

Compost is very beneficial, both naturally and economically. Some examples of these benefits are:

- Homemade soil
- Respecting the environment
- Locally grown food
- Home grown food
- Saving 78$ on garbage stickers annually
- Less time dealing with garbage

Save 25% Specific Compost related Products.
Call: (630) 637-9200
for more information

Save 10%
On Compost related supplies.
Call:(630) 778-6710

Thanks For Listening!

We Appreciate Your Time and Your Support In Helping
To Make Lisle A Greener City