Anaerobic Digestion for Rutgers

An analysis of anaerobic digestion for the disposal of food waste and its potential advantages for Rutgers University

Tag words: Anaerobic digestion, Rutgers, Food waste

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Summary

Food waste can be recycled just like paper and plastic. Food waste is rich in organic materials, rich in carbon and hydrogen. Combinations of carbon and hydrogen can produce large amounts of energy. Fuels, like gasoline, are made of long carbon and hydrogen chains. Being that these elements are present in the food that we throw away every day, it is a waste to not utilize them. Processes such as anaerobic digestion can convert carbon sources in food waste into methane which can be burned to produce energy. Anaerobic digestion also produces natural fertilizer which can be used to fertilize crops. This process would be very useful and practical if implemented at Rutgers University, which currently pays to have their food waste hauled away. This is a waste of a potentially valuable carbon source which has yet to be tapped. If Rutgers were to implement this system of food waste disposal, the University would become much more environmentally friendly and be able to produce some of its own electricity. For this reason, a petition has been created to gain support for implementation of anaerobic digestion at Rutgers. Once completed, this petition will be presented to dining services in an attempt to have this system put in place.

Video link: http://www.youtube.com/watch?v=k23XwexIYEw

Food waste: Its problems, and its solutions

1.1 Compost

(KP) Compost is an organic material which has been decomposed with soil microbial activities and this can be used as a fertilizer. Most of the organic farming that is growing all over the world uses the compost material. In order to make compost, first a pile of organic material is required then the process of breaking down that material or the process of decomposing occurs. This process usually takes five to six weeks period. The proper decomposition requires regularly turning the organic mixture and adding the plant leaves, which is very rich in organic compounds and adding water. Decomposition is aided with aerobic bacteria, fungi and some worms. The fungi and worms breaks down the macromolecules and aerobic bacteria works as a catalyst of this process. Aerobic bacteria gives heat by producing carbon dioxide and it also produces ammonium. With the special bacteria, known as nitrification bacteria further converts the ammonium into nitrites and nitrates, which is a very common source of nitrogen for the plants. This process occurs naturally in the ecosystem, where these bacteria are living in the nodules of the plant.

1.2 Uses of compost

This kind of organic rich compost is very beneficial to lands and commonly used as fertilizer landscaping, agriculture and gardening. Compost can also be used for control of soil erosion, construction of wet lands and reclamation of the water bodies and land. Compost can be apply to garden directly or it mixed with soil or mulch, this provides a very good medium for growing plants, this helps in providing nutrient to plants in terms of nitrogen, because of this quality, when mixed with soil, the soli become porous so the soil become reach with air, it helps to hold the moisture and other necessary minerals important for pant due to the compost absorptive nature. Overall compost in planting increases the fertility of the soil. Composting can destroy unwanted weed and protect the plant from pathogens.

1.3 Composting: a multi-step process

Microorganisms are used in decomposing organic martial. Microbes break down macromolecules to its simplest form. The finished compost is very rich in fiber, a carbon containing humus and nitrogen, phosphorus and potassium, a necessary nutrient for life. The process by which the microbes break down the organic material is by aerobic and anaerobic conditions. Both processes have their own advantages. However, anaerobic process also produces methane gas which can be used as energy source. In anaerobic composting microbes break down food waste, leaves, paper, manure and coffee ground and many other material produced mostly from human waste. Today most of food waste is being end up in the landfills. This is just a waste of organic matter, which can be use full as energy source and composting material.

Microorganisms use:

There are many microorganisams that can used in process, but most commonly used bacteria are acetogens, archaea, mesophills, thermophills, methanogenes, nitrogen fixing bacteria and actinimycetes (a type of fungi).

Acetogens breaks down organic matter and produce acetic acid, methanogens produces methane gas from the carbon containing compounds. During decomposition there is conversion of molecules into sugars and hydrogen acetic-acid before the microbes produces methane gas. For the successful digestion temperature should be between 35to 45 degree Celsius, which is optimal temperature for biological processes of the bacteria. If the temperature is too low then there is no decomposing and if the temperature is too high then the microbes will die.

Methanogens which produces methane comes from hydrothermal vents and the optimal temperature for them is very high; between 55-60 degree Celsius. One of the advantages of using these bacteria is that, it can survive at very high temperature and no continuous addition of bacteria culture is required. Conditions at which microorganisms grow are needed to be considered. In an anaerobic process the environment should be oxygen free. Therefore the container should be sealed tightly to prevent the oxygen gas out of the container. The needed oxygen is provided from the organic matter, oxides are always present in food waste. Because outer source of oxygen is prevented the intermediate products will provide alcohol, aldehydes, organic acids and carbon dioxide. Lastly, methanogens coverts these intermediate products into methane, carbon dioxide and some hydrogen sulfide. The population of microbes is also very important; common process of introducing the microbes is called seeding process, which is from sewage sludge or cattle slurry.

First step of decomposing is hydrolysis or liquefaction. In this step, the bacterium converts the insoluble molecule cellulose into soluble molecules such as sugars, amino acids and fatty acids, and the polymers. Which are then converted to even smaller units known as monomers by using various enzymes from microbes. Most of the food waste is rich in lipids, Polysaccharides, proteins and nucleic acids.

In the second stage acetogeneis are used. Acetogenesis converts the organic food waste into acetic acids, carbon dioxide and hydrogen. Other organic acids are proionic acids decomposed via syntrophobacter wolinii, butyric acid decomposed via sytrophomonos wolfei and ethanol.

In the third stage methanogens are used. The products produced by the acetogeneis is converts into even simpler from, which is methane gas. The bacteria used are methanobacterium, methanobacillus, methanococcus.

This process is divided into four steps, which includes the pretreatment, waste digestion, gas recovery and residual treatment. First it requires shredding of organic food waste and there should a separate container to collect biogas and the remaining solid should be aerobically curd to obtain a compost product.

1.4 Important parameters for anaerobic digestion

The rate at which the digestion will work properly is depends on many steps. The parameters are Waste composition, pH level, temperature and carbon to nitrogen ratio. Waste composition should contain any thing that is organic, which includes cardboard rolls, clean paper, coffee fronds and filters, cotton rags, eggshells, fruits and vegetables, grass clippings, hair and fur, leaves, house plants, sawdust, news papers, wood chips and yard trimming. The waste should not include the following products; coal or charcoal ashes, black walnut tree leaves or twinges; bad for plants, dairy products, meat or fish bones. The pH of the digest should be between 5.5 and 8.5. The carbon to nitrogen ration should be between 20to 30. In addition to all these parameters, frequent mixing is also required. Proper mixing provides equal temperature to the whole digester and prevents scrum formation.

1.5 Products from Anaerobic digestion

There are two main products produced from an anaerobic digestion; methane, compost, and water. Methane can be used to produce electricity and heat. The compost can be used as fertilizer.

1.6 Financing an anaerobic digester

Most digesters hold 65 foot diameter complete mix-stair tank, which has capacity to hold about 550,000 gallons. This can also hold the temperature of about 98 degrees to 104 degrees for about 24 days, a necessary time for complete anaerobic digestion. Instead of purchasing AS system of Turkey, which is mostly used in the United States of America, it is batter to buy a package from Europe. Packages from Europe are less expensive and come to install anaerobic digester. Also, replacement parts are easily available. Biogas generated by digester fuels an I-power combined heat and power system. The waste produced of the system, can be used to warm digester tank via heat exchanger. Liquid product produced by the digester run through a dissolved air flotation (DAF), which separates solid from liquid. The estimated cost for this system is around $ 1 million, which includes $350,000 main digester, $70,000of liquid storage, $75,000 construction cost, $150,000 electrical generator, $ 55,000 a separate equipment, $100,000 the DAF and $50,000 a pellet mill. It would cost an additional $1 million to get the machinery to convert the methane to electricity. To finance this in Rutgers, grants can facilitate financing.

1.7 Universities that recycle Food Waste

Kean University in Union New Jersey has aerobic digester which is capable of processing 1,000 pounds per day on campus generated food waste. Wood chips are added to increase carbon source addition of wood chips to the digester just cost under $300 and this lasts for a month. Kean coverts about 60 tons of food waste per year. Then the finished compost is used for landscaping, garden and farms. Berea College in Berea Kentucky has been composting for twelve years. They received grant for digester from Department of Agriculture and Natural resources. This college uses compost in managing farms of about five to eight acres. They also have system in dining hall to keep food waste separate from other garbage. Dickinson College in Pennsylvania uses compost to grow vegetables that can be used in college kitchen. State University of California launched composter program in 1995, which was first, ran on the grants from dining halls. This university's composter for most part is handled by students as work study program and some university professors. University of North British used the compost to sell to the local farmers and for household gardens. The University sells a bag f fertilizer for five dollars. Other universities like university of Pennsylvania, Syracuse University and many others have already took initiative step to conserve energy from waste and all universities should take this kind of economic and environmental sustainable initiative.

1.8 Environmental benefits

The great amount of food waste that is produced causes many economic and environmental consequences. In the United States of America, percent of food waste is the highest then all other waste, even grater then plastic bottles. When food waste is just thrown in landfills, it releases methane gas as the food waste degrades. This increases global warming twenty one times more than carbon dioxide. However, if methane is collected from the food waste efficiently, then methane gas can be used as energy source. As the energy crises increases all over the world, anaerobic digester is good way to sustain energy or fuel. In addition, when another byproduct of anaerobic digester; organic fertilizer can benefit our environment. Organic fertilizer can improve soil quality and health; it can help in drought resistance, and reduction of pesticides. Food waste piled up on landfills can increase chance of new decease or toxic bacteria that grow on decaying food waste.

1.9 Carbon Foot Print of Food Waste

Estimation of carbon footprint from food waste produced by Rutgers per day:

Rutgers University pays a pig farmer $120,000 to pick up food waste. It is hard to believe, the farmer has enough pigs so all 30 to 50 tons of food waste is eaten by these pigs. One pig eats on average of 8 pounds. Average density of food waste is 7.3 pounds per gallons. Therefore, 40 tons of food waste would equal to 80,000 pounds of food waste per day. If a pig eats eight pounds of food per day, then the farmer would need at least 10,000 pigs in his farm. When considering environmental effects of food waste carbon footprint is important factor to consider. Carbon foot print is a measure of impact of people activates on environment, and climate change. Carbon footprint measures all greenhouse gases. Carbon foot print for food waste in landfill is 7.9 tons of carbon dioxide per one ton of food waste. If all the food waste of Rutgers was piled on landfills then it would produce 316 tons of carbon dioxide per day. Four pound of bone less pig produces 8.8 pounds of carbon dioxide footprint. Average weight of a pig is 230 pounds. 10,000 pigs would produce 1084 tons of carbon foot print per day, assuming 30 percent of pig anatomy is made of bone and whole pig is producing carbon dioxide.

1.10 Artificial fertilizer verses organic fertilizer

Fertilizer can be organic or inorganic and it can be natural or synthetic material that is added to soil to promote nutrition to soil. A fertilizer usually provides six macronutrient and seven micronutrients. Macronutrients are nitrogen, phosphorous, calcium, magnesium and sulfur. Micronutrients are boron, chlorine, copper, ion, manganese, molybdenum, and zinc. Organic fertilizer or compost is one of the byproduct of anaerobic digester. Compost has known to improve biodiversity, soil life and high productivity of soil. Compost can also help deposition of excess carbon dioxide for pants. Compost can increase soil organisms like bacteria that are important for the help of plant and these organisms play a major role in regulating food chain. The compost can also provide micronutrients for these organisms, the organisms includes mycorrhiza, which aids pants in absorbing nutrients. Most importantly compost can reduce external inputs of pesticides. Inorganic fertilizers are usually synthesized by the process of Haber-Bosch process that produced ammonia as nitrogen source for plants. Inorganic fertilizer can provide bulk of nutrient to plants; however it can provide an easy tool to absorb all these nutrients. Any kind of artificial material that disturbs basic food chain has some kind of long term harmful effects. Just like global climate changing due to imbalance of carbon cycle. Inorganic fertilizers are easily washed away by water, which causes pollution and loss of oxygen. Improper break down of fertilizer causes algae blooms. Many times synthetic fertilizers are overly used and cause tissue damage and dehydration of plant. High concentrations and repeated use of fertilizer may build toxins in soil and makes the soil more acidic. Inorganic fertilizer usually reduces soil fertility by stimulating the growth of organisms that compete for nitrogen source. In addition, many beneficial microbes can be depleted by the chemicals in the fertilizer. This makes the soil hard and unproductive. Converting food waste into compost can provide soil healthy in nutrients and in enough amounts, therefore converting food waste into compost can be beneficial to environment in two ways. Compost production in Rutgers from food wastes is more than enough to be used on maintaining plants and lone at Rutgers. The access fertilizer can be sold to the local farms located near the universities and during summer it can be sold to house gardeners in lower price.

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1.11 Problems caused by food waste and solved by anaerobic digestion

(MT) The anaerobic digestion of food waste has the potential to address many problems directly and indirectly associated with food waste. This process has the potential to alleviate issues such as the wasting of fuel to pick up waste material, the problems with filling landfills, and problems with artificial fertilizers.

The major problem with food waste in general is how much space it takes up. The sheer mass of all the wasted food can take up valuable space in landfills and is contributing to the fact that landfills are becoming rapidly filled. Currently, the Middlesex county landfill handles approximately 500,000 tons of waste each year.[1] About 12% of this total waste is food waste.[2] The landfill will only be in operation until it is filled to its maximum height of 165 feet, covering 300 acres of land. This is projected to occur after the year 2020.[1] Once filled, the county will have to set aside another large piece of land for waste disposal. This is hardly a sustainable practice and the vast amount of food waste produced only contributes to this problem. Furthermore, only about 2.8% of food waste is composted.[2] Landfills will soon become filled and space to put new ones will run out. Because of this, new ways of dealing with our waste must be utilized in order to alleviate this problem.

People who do not wish to have their food waste put in a landfill must seek out alternative ways to deal with their waste. Some alternatives include composting and digestion of the waste. These processes can be done on a small scale to deal with the waste of a single household. All that is needed is a small area outside and some supplies from a local hardware store. There are advantages to dealing with food waste in this way. One of these is that both of these processes produce nutrient rich fertilizer which can be used in a home garden. Another advantage is that it vastly reduces the amount of trash each family puts into a landfill. This can save the users money as well. Both processes are beneficial for the person using them and for the environment as a whole.

Businesses and universities, which produce much more food waste than the average household, and which do not wish to landfill their waste, run into problems associated with the sheer mass of waste they deal with. Currently, Rutgers deals with their food waste by paying a pig farmer to haul away the waste daily. One problem associated with the current method of dealing with food waste on campus is the amount of fuel used in the transport of this waste. Currently, a pig farmer picks up food waste from all four campuses daily. As the farmer picks up 30-50 tons of waste daily, a significant amount of fuel is consumed over the course of the year. This, of course, has an impact on the environment in that the combustion of fossil fuels produces carbon dioxide, a greenhouse gas. This impact is even greater considering the amount of gas needed to make the trip from the farm to campus each day given the poor gas mileage of a large truck. This environmental impact becomes unnecessary when the process of anaerobic digestion is considered. The same process that can be used for a single family's waste can be scaled up to handle the waste of a large establishment. The process will allow for much of the university's food waste to be processed on campus without the need for numerous lengthy trips to and from the farm. Also, the university could save the $120,000 they pay the farmer annually to haul away the waste. Another problem that anaerobic digestion on campus addresses is that it eliminates the University's dependence on the pig farmer. If the pig farmer happens to not show up one day, the University has a big problem on its hands. It must then find another way to deal with the day's food waste. One of these options might be for Waste Management to pick it up. However, when one looks at the cost of this, it does not seem feasible. It would cost Waste Management $1498 in just operating costs to compost this waste, meaning they would have to charge Rutgers even more. Anaerobic digestion, however, makes Rutgers completely self sufficient in dealing with its food waste. All in all, anaerobic digestion could reduce the environmental impact of the university's food waste, save money, and make Rutgers capable of independently disposing of its waste.

A considered possibility for the fate of food waste on campus was for it to be shipped to a composting facility in Delaware. This would have an even bigger impact on the environment than if the waste were picked up by the pig farmer. Delaware is approximately 100 miles away from Rutgers. Assuming that the trucks being used to ship the waste get about 10 miles per gallon, 10 gallons of fuel would have to be used in order for one truckload of food waste to be delivered. Food waste in a 55 gallon drum weighs about 400 lbs giving a density of 7.3 lbs per gallon.[2] A large tanker truck can haul about 13,000 gallons of material in one trip, meaning that 95,000 lbs of waste could potentially be transported in one trip.[3] Based on these calculations and being that Rutgers produces approximately 5.3 million pounds of waste per year, 56 trips to and from Delaware would have to be made consuming a minimum of 1120 gallons of fuel. This hardly seems like a viable option as it wastes an immense amount of fuel. It is especially wasteful considering that the waste could have been dealt with on campus. It has been estimated that food waste consumes 300 million barrels of oil each year.[4] The current methods of dealing with food waste on campus are certainly not helping to alleviate this problem. The anaerobic digestion of the waste, however, can save thousands of gallons of fuel and prevent much of the carbon dioxide emissions of the current practices.

Agriculture is believed to contribute about 6% if total GHG emissions in the United States, with about half of the emission from livestock and manure sources. Agriculture is reported as the largest emitter of N2O and the second largest emitter of CH4. In 2006, the FAO reported that worldwide agriculture contributed more GHG emissions than the transportation sector, however in the U.S. the emissions from agriculture are about 25% that of transportation[9].

On agricultural land, an increase in livestock production in turn increases the amount of feedlot manure produced each year. Proper use of the manure is crucial to the sustainability of feedlot operations. The theoretical methane production from pig manure at about 5160 kg^{-1}, more than is obtained from dairy cattle manure[10]. Anaerobic digestion of pig manure can reduce GHG emissions from 1.4 kg CO2 equivalent per kg VS to between 0.4 and 0.8 kg of CO2 equivalent per kg VS. The total amount of GHG that were emitted from swine manure was 1.7 kg Mg GHG in roughly one day.

Pigs eat approximately 4% of their body weight per day and a fully grown pig weighs about 110kg which comes out to be about 240 lbs., that means that the average pig eats about 10 lbs of food per day. The Rutgers campus generates approximately 50 tons of food waste per day or about 100,000 lbs of food waste each day. That would feed roughly 10,000 pigs which all give off about 1.7 kg Mg GHG per day which would bring the total amount of GHG that were emitted from the pigs to 17,000 kg Mg GHG per day. This amount of GHG could be substantially reduced if Rutgers was to implement an anaerobic digester instead of sending off the food to become feed for the pigs.

11.12 Ethical considerations for the current methods

Even if the pig farmer does feed all of the food waste he receives from Rutgers to his pigs, ethical questions still arise from this practice. According to the 1980 Swine Health Protection act, food waste must be treated before being fed to pigs. This act restricts the use of food waste as pig feed and mandates that food waste to be used as pig feed must be heated to 212° F or 100° C for a period of 30 minutes before being fed to pigs[11]. The reason for this heating is so that the meat in the food waste is cooked before it is used as feed. This reduces potential diseases that can be spread through uncooked meat. This heating can be accomplished through steam injection or simple flame heating.

Since the pig farmer uses the 30 to 50 tons of food waste produced by Rutgers for food waste, he must heat it. 50 tons of food waste would take a vast amount of energy to heat to boiling point. It seems as though Rutgers has lost sight of this and has overlooked the fact that it is highly unlikely the pig farmer is abiding by the law and heating the food waste. The University must know of the law and know that the pig farmer is likely breaking it. If this is the case, it is unethical to keep accepting the pig farmer's services. Knowing that something illegal is occurring and turning a blind eye to it is just as bad as the person committing the illegal act. Even if they suspect that something is awry, they should investigate it instead of ignoring it. Rutgers ignoring this possible infraction by the pig farmer is self serving and unethical. All of this can be escaped, however, through anaerobic digestion of the university's food waste.

11.13 Other problems solved by anaerobic digestion

One other issue that anaerobic digestion of food waste can potentially help alleviate is problems associated with artificial fertilizers. The anaerobic digestion process produces a liquid fertilizer rich in nutrients. This can be used in place of the artificial fertilizers that some farmers use. These synthetic fertilizers can cause serious environmental problems. One of these is runoff from the fields in which these fertilizers are used. When rain washes the nutrients contained in these fertilizers into a body of water, it has a negative effect on the ecosystem. It can cause eutrophication which is the pollution of an environment with excess nutrients.[5] The two main causes of eutrophication are excess amounts of nitrogen and phosphorous. These are two major components of synthetic fertilizers and because of this, runoff from fields containing these fertilizers are rich in nitrogen and phosphorous. Also, as demand for food production increases worldwide, the use of synthetic fertilizers is increasing, causing more and more eutrophication.[5] The reason that the excess nutrients have a negative environmental impact is that the overabundance of nitrogen and phosphorous can cause algal blooms which deplete the oxygen in an area and cause dead zones in which limited aquatic growth occurs.[6] This has effects on the fishing industry and the ecosystem overall. The runoff from synthetic fertilizer has overarching effects for the ecosystem.

One other disadvantage of synthetic fertilizers is the fossil fuels required to produce them. Chemical fertilizers are made through industrial processes which burn fossil fuels. This is in contrast to organic fertilizers, like the liquid fertilizer produced through anaerobic digestion, which require minimal fossil fuels. This means that the carbon dioxide output for the production of synthetic fertilizers is much more than that of organic fertilizers. Because of the ecological problems associated with synthetic fertilizers, organic fertilizers are a much better option for growth of crops. The anaerobic digestion of food waste can produce a high quality organic fertilizer which can provide a viable alternative to harmful synthetic fertilizers.

1.14 Advantages of byproducts of anaerobic digestion

Along with the fertilizer it produces, the anaerobic digestion of food waste also produces methane, which can be a useful byproduct. Methane can be used as natural gas to heat buildings and can also be used to generate electricity. Anaerobic digesters are capable of producing up to 8.5 ft^3 of methane per pound of food waste.[7] This methane can be used in a variety of different ways. For example, this process is used in India and the methane produced from one pound of digested cow manure can provide enough natural gas to cook a whole day's meals for 4-6 people.[8] The gas can also be used to run engines. 1.7 cubic meters of methane is roughly equivalent to one gallon of gasoline and to run a gas engine, 0.5 cubic meters of methane are required per horsepower per hour.[8] This represents a renewable source of energy for daily functions such as heating and transportation. In addition, the methane can be burned and used to produce electricity. It is estimated that over a 15 day period, the methane produced by an anaerobic digester can be converted into electricity at a rate of 250 kWh per ton of wet food waste. All these benefits associated with methane production make the methane producing process of anaerobic digestion much more attractive.

With the vast amount of waste that Rutgers produces, much methane could potentially be produced through anaerobic digestion of this waste. Rutgers currently produces 5.3 million pounds of food waste per year. This amount of waste can produce hundreds of thousands of cubic feet of methane. This is a very large amount of methane and can be used as a renewable source of energy for the university.

With this vast amount of natural biogas produced from the anaerobic digester, Rutgers could heat buildings and produce electricity for use on campus. The biogas produced on campus would be capable of generating 2.37 MkWh of electricity for the university. At $0.13 per kWh, this represents $308,000 worth of electricity produced annually. Also, if the gas was used for other purposes such as heating buildings, other energy costs could be cut. All of this makes the university more environmentally friendly.

The savings on energy costs, coupled with the savings associated with not paying the pig farmer to haul away the waste, make anaerobic digestion a feasible option for the university. These savings could offset the cost of the actual machine needed to carry out large scale anaerobic digestion. Given the approximate $2 million investment, for the digester and machinery to convert the methane to electricity, the project would pay for itself in 5 years. This is based on $428,000 annual savings from electricity produced and money saved by no longer needing the pig farmer. There are three possible payment plans for the anaerobic digestion system. The first involves Rutgers paying directly for the equipment and owning it. This would allow the university to either use or sell the energy it produces. The second option involves Rutgers leasing the equipment with the option of later purchasing it once it is proven to work. This lowers the upfront cost of the project. The final option is that the company who makes the machine, UTS, owns the machine and Rutgers would pay for the electricity that it produces. It is suggested that Rutgers choose either of the later two options as it may be difficult to come up with the upfront cost of owning the machine fully.

The process also decreases the university's impact on the environment. It reduces fuel needed to transport the waste and also reduces the need for outside electricity and gas. There will always be food waste at the university and coupled with anaerobic digestion, this means that there will always be a renewable source of energy on campus. This, along with the fact that it would make the University's waste management practices much more sustainable, makes anaerobic digestion of food waste on campus an idea worth seriously considering. This sustainable, renewable source of energy cannot continue to go untapped.

1.15 Conclusion

Anaerobic digestion provides many advantages over the current system of disposing of food waste at Rutgers. The current method is wasteful, as a valuable carbon source, capable of producing energy, goes to waste. Anaerobic digestion can generate valuable electricity and fertilizer for the University through a practical system which will pay for itself in a relatively short period of time. It solves issues such as making Rutgers self sufficient and not reliable on a pig farmer whose pigs produce the powerful greenhouse gas methane. All in all, anaerobic digestion at Rutgers provides a real alternative to current methods of food waste disposal which generates useful byproducts and makes the University more environmentally friendly.

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Service Project

Anaerobic digestion is a much more environmentally friendly alternative to Rutgers' current method of dealing with food waste. It is a real possibility to have this system implemented at Rutgers. The 30-50 tons of food waste generated daily could be easily handled by a large scale digester and instead of going to waste, the food could work in our favor, generating electricity and fertilizer. This is not financially unfeasible either. The waste in the digester would produce about $100,000 dollars in electricity annually from the methane it produces. This, along with the savings from no longer having to pay the pig farmer to haul away the waste, represents a savings of around $200,000 per year. This means that the initial investment for the equipment required for digestion and energy conversion will be paid for by the system itself in 10 years. For this reason, we propose to have an anaerobic digestion system implemented at Rutgers to handle all its food waste.

In an attempt to accomplish this, first we collected information on food waste from Dr. Fagan. We then we created an online petition on change.com in order to gain support for this proposal. The link to the petition is http://www.change.org/petitions/rutgers-the-state-university-of-new-jersey-to-install-anaerobic-digester-to-handle-food-waste. We wished to make students aware of the problems associated with current methods of food waste disposal at Rutgers. Once students are aware of the problem and see the possible solution, they can sign the petition in support of implementation of the new system. To promote our petition, we first e-mailed SEBS student govern council to e-mail the members of their organization. We then emailed NJPRIG to put our petition on their web-site. Also, the petition was uploaded on Rutgers' Facebook. Andy Campbell was contacted to E-mail this petition to all Rutgers students. In addition, the president of the Rutgers SEA was emailed and our petition was put on their Facebook page for their members to see. This is how we promoted our petition to Rutgers students.

Once completed, this petition will be presented to dining services in order to show that there is support for anaerobic digestion on campus. Along with this, a cost benefit analysis will also be presented to show the financial and environmental benefits of such a system. After this presentation, we hope that Rutgers will seriously consider anaerobic digestion as an alternative to its current methods of food waste management.

As an addition to this project, a small anaerobic digester was built to demonstrate the nature of anaerobic digestion and how simple it can be. Anaerobic digestion can be used on a large scale in order to handle the waste of a large organization, business, or school. This is not practical for widespread use by individuals. No household is going to have its own industrial scale anaerobic digester. Luckily, the process can be scaled down to accommodate the relatively small amount of waste produced by a single household. Small anaerobic digesters can be made relatively inexpensively from items sold at any hardware store. These mini digesters can process dinner scraps and other food waste.

All that is needed to make a basic mini anaerobic digester is a plastic bucket with a lid, a pipe threaded on both sides, a valve, and a nozzle. First, a hole the size of the pipe must be drilled into the lid of the bucket. The pipe is then threaded through the hole and threaded washers are screwed onto the pipe both above and below the lid in order to keep it in place. A valve is then screwed onto the top of the pipe. The function of the valve is to keep gas from escaping and entering the vessel during the beginning of the digestion process. Since the process must remain anaerobic in order for methane to be produced, the valve prevents oxygen from entering the vessel. It also keeps the produced gas inside until you want to release it. The final piece of the mini digester is the nozzle that screws into the other side of the valve. This allows the method of gas collection to be attached. This could be a hose that is attached to the digester.

To demonstrate the ease with which one of these mini digesters can be built, I built one out of the parts stated above. I used a Home Depot bucket for the body of the digester. This along with the lid cost $4. For the pipe connecting the bucket to the valve, I used a 1 ¼ inch diameter black steel nipple which is 5 inches long. This cost about $3. I used a valve sized to fit the threading on the pipe. This was the most expensive component and cost $5. The valve with one threaded end, sized to fit into the other side of the valve, cost about $2. In all, my basic mini digester cost only about $14 to make. The most difficult part of building the digester is drilling the hole to thread the pipe through the lid. This being said, the construction is very simple and quick.

Once built, the digester is ready to start breaking down everyday food waste. Into the bucket first goes water and some shredded newspaper. Septic tank bacteria are then added to the bucket. These bacteria are responsible for carrying out the reactions which produce methane and the other byproducts of anaerobic digestion. If these bacteria aren't added to the mixture, the food waste will not decompose, at least not at any kind of reasonable rate. After the addition of the bacteria, food waste can begin to be added to the bucket. Any type of fruit or vegetable is ideal for the digester because it provides a good carbon source that the bacteria can easily convert to methane. Meat does not work as well as fruits and vegetables.

In order to collect the gas produced by the mini digester, I attached a balloon to the nozzle. Since this was just for demonstrative purposes, this was a sufficient method of gas collection. Over time, the balloon began to fill with gas. This gas is a mixture of carbon dioxide and methane. The reason for this is that at the beginning of the digestion process, the process is not yet anaerobic. Oxygen is let in when the various components are added to the bucket. In the presence of oxygen, carbon dioxide is produced. When this oxygen is used up, methane begins to be produced. This imperfect method is sufficient for demonstrative purposes or for someone who only wishes to extract the fertilizer produced inside the digester.

Somebody not using the mini digester for demonstrative purposes, who wishes to produce usable methane, can do so using the mini digester. The mixture of carbon dioxide and methane gas cannot be efficiently burned so the methane must be isolated from the carbon dioxide. This can be accomplished by passing the gas mixture through an NaOH solution. The carbon dioxide reacts with the sodium hydroxide, eliminating it from the gas mixture. This leaves usable methane which can be burned and used for purposes such as powering an outdoor grill. If usable methane is the goal, a larger digester may have to be built. Larger digesters can be made out of 55 gallon drums. Other improvements can be made to the system to make it more efficient. While these larger, more complex digesters are more expensive and more difficult to build, they produce much more usable methane. This methane could potentially be used for cooking or heating.

Anaerobic digestion, whether on a large scale or small scale, provides many benefits. With a little help, we can change the paradigm of how food waste is dealt with at Rutgers University.

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Letters to the Editor

Anaerobic Digestion as an Alternative to Current Food Waste Practices

(MT)- Daily Targum

Here at Rutgers, tons and tons of food waste is produced daily from the dining halls. 30 to 50 tons of food waste is produced daily by the University. In order to deal with this vast amount of waste, Rutgers pays a pig farmer over $100,000 dollars annually to pick it up and haul it away. This method is completely wasteful. It wastes fuel, and money. This method also produces much unnecessary pollution. An alternative to this wasteful method is anaerobic digestion of the food waste. This process is capable of handling all the food waste at Rutgers and produces useful byproducts like fertilizer and methane which can be used to produce electricity. Let's just focus on the financial aspect for a moment. An anaerobic digester, capable of handling all the school's food waste, along with machinery needed to convert the methane produced into electricity would cost approximately 2 million dollars. The methane produced by the digester would be capable of producing over 2.37 MkWh of electricity. At $0.13 per kwh, this represents $308,000 in electricity produced annually. This, along with the money saved from not having to pay the pig farmer, would allow the digester to pay for itself in about five years. Saved money from this process can go to improvements at the University and may even help lower tuition.

Along with saving the University money, this method will also make Rutgers more environmentally friendly and sustainable. Every little bit that we can do to help the planet counts and this would be a major step towards a completely environmentally sustainable campus. We are currently working on a petition in order to get the process of anaerobic digestion implemented at Rutgers. The link to the petition can be found below. Please sign and help better our system of food waste management!

http://www.change.org/petitions/rutgers-the-state-university-of-new-jersey-to-install-anarobic-digester-to-handle-food-wate?share_id=YTYzbcHYPG&pe=pce

Martin Tricarico
Junior: Rutgers University

Do we really need to throw all food waste in landfills or give to pig farmers?

(KP)
Tons of food waste is produced each day. Until now we have recycled papers and plastics, but now we can recycle food waste as well. Many countries in Europe and south Asia recycle food waste into compost and methane gas. The United States of America have very low activity of recycling, approximately three percent out of 34 million tons of food. However, many universities in USA, like Kean University, Allegheny College and Dickinson College and many other universities have taken initiative action to recycle food waste and schools are the best place to start educating new generation about food waste recycling benefits to ecosystem and economy.

Rutgers the State University of New Jersey produces 30 to 50tons of food waste daily. Right now Rutgers pays $12,000 to a pig farmer to pick up this food waste. This is not the best method to handle food waste as it wastes. Anaerobic digestion is an alternative and better way as it produces liquid fertilizer. Methane gas can be used to heat buildings and generate electricity, providing a renewable energy source for the university. 450 million cubic feet of methane can potentially be produced annually from all the food waste at Rutgers. This natural gas can be used to produce over 2.37 MkWh of electricity for the university annually, representing about $308,000 in savings. Given the million dollar investment that this project takes, the initial investment can be paid off in just 5 years due to the electricity produced and the fact that the university will no longer have to pay the pig farmer.

This letter is to aware Rutgers the state University of New Jersey, students and their patents that if Rutgers invests money on anaerobic digester then this can help students on their intuition. Tuition fees are collect from students, so Rutgers can provide electricity and other facilities. Rutgers student class 11:015:407 of 2011 want propose this idea of installing anaerobic digester. To write a letter we need petition from Rutgers students. To sign this petition please visits web page http://www.change.org/petitions/rutgers-the-state-university-of-new-jersey-to-install-anarobic-digester-to-handle-food-wate?share_id=YTYzbcHYPG&pe=pce
Your sign will benefit Rutgers students, economy and ecosystem.

Kirmi Patel

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