**Review of Literature**

**Problem Statement**

Across the globe many issues face rural families every day, but one in particular is a lack of potable water and proper sanitation. For many, running water and proper waste disposal is an on going problem; this not only affects their food supply but as well as their livelihood.The issue at hand is that many latrine systems in 3rd world countries are inadequate in disposing waste and other fecal material. With unpredictable weather with the ability to move fecal material from the pits they reside in to the local waterways. As well many studies have show that fecal material has also gain access to the previous clean water sources through human contact and contamination. This in turn can cause problems like water contamination that can lead to health complications and even death in some cases. In addition to the possibility of death, it’s a never-ending cycle. There is constantly a need for new latrines to be built.

One could consider water and sanitation conditions in Honduras to be one of the biggest environmental barriers. “Over 2.2 million people lacked access to improved sanitation services, and 1 million lacked access to improved drinking water services in 2010, of these, 66 percent and 80 percent, respectively, live in rural areas”(UNICEF 2011). There have been many relief efforts in recent years, but this is not enough to correct all the problems Hondurans face on a daily basis. “In 2006, the Honduran government reported 34% of the district's people lacked access to safe drinking water and 43% lacked proper sanitation (Kosowatz 2012).” With this major absence of clean drinking water and sanitation, “Only 79% of individuals living in rural Honduras use improved water sources. Inadequate drinking water quality is related to diarrheal illness, which in Honduras contributes to 18.6 episodes of diarrhea per child per year in children under five years of age (Rural Remote Health 2014).”

Developing countries like Honduras also face a major disadvantage due to the fact that many of the poor rural farmers lack the financial ability to pump water to their fields, as well as access to agricultural information and modern farming techniques. Not only is it a barrier for the common man, it also greatly effects the farmers ability to produce. Due to lack of irrigation and overall rainfall in Honduras, their agricultural productivity has come to a stand still. Many of the native farmers and their families have to travel to great lengths to find water that they can haul back to water their crops with. The Gutierrez family experienced this quite often: “ Each day during the growing season, she, her husband and their eight children would make several trips to a river about 40 minutes away and carry back five buckets of water to replenish their plants (Washburn and Usher 2014).” Improving the water and sanitation in Honduras, specifically for those in the rural section of the country would improve their overall well being. If water was more accessible to rural farmers their crops would not only be more nutritious but there would be a larger quantity of them. In turn it could mean an income for rural farmers, this would then reduce poverty levels in rural Honduran families and then from there the money would trickle into the economy, creating an overall increase in living standards for Hondurans.

**Pre-existing Solutions:**

Overall water and sanitation in Honduras has improved immensely due to the help of many religious based organizations as well as many sponsored initiatives by the government. Many of these organizations keep records of their progress and share this with as many people as they can reach in hopes they will help. For instance the ASME (American Society of Mechanical Engineers) reported that: “WMI's solution, called the ‘Healthy Latrine,’ still is basically a pit-type latrine but uses a standard flush toilet, without the tank, making it cleaner and healthier than a standard pit design. The project has been an overwhelming success based on studies done in 2010 some 10,000 new latrines had been built. The work showed an 80% improvement in the number of people tested for parasites and a 50% decline in the number of diarrhea disease cases reported to local health clinics (Kosowatz 2012).” In order to combat the growing epidemic of water and sanitation, organizations and corporations like ASME (American Society of Mechanical Engineers) continue their work, by implementing the “‘Living Water Treatment System, a safe drinking water package that uses filtration and chemical disinfection to produce clean drinking water. It operates on solar energy, and produces 1,000 gallons of water for less than 75 cents. (Kosowatz 2012).”

In conclusion, based on Honduras’s overall lack of water and sanitation there is a need for new systems, technologies and financial resources to combat this epidemic. Correcting these problems would not only benefit the health of many rural communities but would also help them in multiple ways, including: improving the quality and quantity of food, reducing poverty and bettering the economy.

**Solution**

I am proposinga paradigm shift in toilets that will not only change the way we view sanitation but fossil fuels as well. The concept is a self-contained, decomposing latrine system that could turn raw materials such as human feces and food scraps into fuel, specifically biomethane, if in the right environment. Based on my research biomethane is: “a naturally occurring gas which is produced by the so-called anaerobic digestion of organic matter such as dead animal and plant material, manure, sewage, organic waste, etc. (biomethane.org.uk).” Anaerobic digestion is a group of processes by which microorganisms decompose biodegradable material in the absence of oxygen thus creating biomethane (Wikipedia). “Since biomethane is chemically identical to natural gas, it can be used for the same applications as natural gas. It can be used for electricity generation, water heating, space heating, cooking as well as to fuel vehicles (biomethane.org.uk).” With such an idea in mind, harnessing and using biomethane to not only pump water for farm irrigation and potentially provide a few hours of electricity at night, this could be a life changing innovation for many. My goal is to create a working prototype to then measure the about of biomethane produced from the decomposing material. From there, I want to take it one-step farther a look at its scalability to determine whether or not it could be applied in a real world setting.

**Concept And Design**

**Iteration 1:** The initial design started with a rotating, horizontal drum (five gallon bucket) that would have agitators (similar to one found inside a dryer) lining the wall of the drum itself. From that point the horizontal drum would be connected to a second vertical drum (five gallon bucket) by a flexible delivery pipe. There would be a single Y-shaped plug of my own design to seal the top of the horizontal drum and the initial opening of the delivery pipe. The vertical drum would have a bladder in the base of the drum as well as a water spigot on the top of its sealed lid.

**Iteration 2:** Unfortunately as I review my initial design concept I found some rather big flaws in its design. First issue that was noted was the fact that with a spinning horizontal drum there was no way to keep a tight seal to the delivery pipe, in additions to it’s lack of feasibility. From there I realized that my Y-shape plug was rather idealistic in a sense that if it ever broke a Honduran farmer most likely wouldn’t have the tools to fix it. With these problems in mind, I was determined to come up with simple yet logical solutions.

**Iteration 3:** With the realization that my previous design would be inefficient, I re-worked my design and came up with the following concept. I decided to put a horizontal drum (five gallon bucket) that is in set in a plastic container (Tupperware Box). With in the horizontal drum, I constructed hand crank connected to a PVC pipe rod with off set arms made out of PVC pipe instead of having the drum rotate itself. Connected through both the plastic container and the horizontal drum is a stationary delivery pipe with an RV valve on either end. From that point it was connected to a second, vertical drum (five gallon bucket) that has a lid with a water spigot connected to the top and a bladder (beach ball) lining the bottom of the tank.

**Iteration 4:** But even as I began to build my prototype, I came across small design flaws that I had to improve on. At one point I tested my prototype by blowing air from and air compressor through it to find out how air tight it, unfortunately I realize that it wasn’t around the delivery pipe. I decided the best way to fix this issue was to create This became the design for my final prototype that I am using to conduct my experiment for this science and engineering fair.

**Inspiration:**

This design came about when I was doing research for my World Food Prize paper. Throughout this progress I found a transit bus company in the UK that ran on fecal material and was utterly fascinated by this concept. With that idea in mind I decided to do some more digging and found out about the concept of a bio-digester. A bio-digester is a device or structure in which the [digestion](http://www.merriam-webster.com/dictionary/digestion%204) of organic waste matter by [anaerobic bacteria](http://www.merriam-webster.com/dictionary/anaerobic%20bacteria) takes place with the production of a burnable [biogas](http://www.merriam-webster.com/dictionary/biogas) and a nutrient-rich slurry (Merriam-Webster). With these ideas in mind I came up with my concept of combining a bio-digester and a latrine together to see if it would possible to sequester biomethane from human feces and other compostable items from the human diet. So with all that I gain throughout my research and my prior knowledge of composting I decided to put it in to action and get to work on a basic small-scale model.

**Relevant, Reasonable and Economic**

One of the main worries of my project is that it’s not relevant to the people of Honduras or there needs, but I believe that it is just the opposite. With a rising need for new innovative solutions for sanitation and water issues across the globe, the decomposing toilet that will create biomethane would be at the forefront of this innovation. With its ability to limit fecal contamination of natural water source and produce biomethane to provide some needed light, help cook a meal or irrigation for farms would be a big step in the right direction. As I mentioned earlier, the situation in Honduras is deplorable in regards to their current sanitation systems. They often have issues with fecal material from their latrines leeching into their main water sources; in turn this same water is used to water their fields. This leads to contamination and health issues for all involved, but I believe that my project with help to mend these issues in a very relevant, reasonable and economical way.

This project is one that is not only reasonable but I feel that is very much feasible as well. With the farmers kept in mind, I wanted to keep my design simple and with the least amount of moving parts to insure that if any problems were to arise that they would be able to repair them on their own. It’s got a moderate design in a sense that anyone with only a small budget and or basic knowledge of construction would be able to assemble this product. In conclusion, I feel that this is very feasible for farmers in Honduras or really any third world country for that matter.

From an economic standpoint the decomposing toilet is both feasible in terms of a small- scale prototype as well as a large-scale model. The small-scale prototype and the large-scale model are both practical in terms of parts and in reference to application. Keeping the farmers in mind, most if not a majority of parts can be purchased at your local hardware store. In addition, I made sure to have the least amount of moving parts to prevent any possible malfunctions.

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| **Life Size Model Parts List** | **Cost** |
| 3"x 10' PVC Pipe | 9.7 |
| 3/4" x 10' PVC Pipe | 2.1 |
| PVC Cement/Primer Combo | 8.39 |
| 3" DWV Male Apapter  | 6.1 |
| 3/4" PVC Cross | 24.8 |
| 3" DWV  | 5.6 |
| 3/4" PVC EL 90D | 1.06 |
| 3/4" PVC Cap Slip | 10.6 |
| 3" Tank to Bowl Gasket for Cadet | 13.96 |
| Rigid Locknut 3" Steel | 3.4 |
| 2.8oz GE Silicone | 3.98 |
| Rigid Locknut 3/4" Steel | 1.04 |
| 3/4" Boiler Drain | 5.98 |
| 5GAL Leakproof Lid x3 | 5.04 |
| 3" Bladex Waste Val x2 | 19.98 |
| PolyJohn Portable Restroom | 712 |
| Tire Inner Tube | 12 |
| Fishing Tote | 462.25 |
|  |  |
| **Total:** | **1307.98** |
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| **Prototype Parts List** | **Cost** |  |
| 18G Latch & Carry-Clear | 13.97 |  |
| 3"x 10' PVC Pipe | 9.7 |  |
| 3/4" x 10' PVC Pipe | 2.1 |  |
| 5GAL Leakproof Lid | 3.36 |  |
| PVC Cement/Primer Combo | 8.39 |  |
| 3" DWV Male Apapter  | 6.1 |  |
| 3/4" PVC Cross | 24.8 |  |
| 3" DWV  | 5.6 |  |
| 3/4" PVC EL 90D | 1.06 |  |
| 3/4" PVC Cap Slip | 10.6 |  |
| 3" Tank to Bowl Gasket for Cadet | 13.96 |  |
| Rigid Locknut 3" Steel | 3.4 |  |
| 2.8oz GE Silicone | 3.98 |  |
| Rigid Locknut 3/4" Steel | 1.04 |  |
| 3/4" Boiler Drain | 5.98 |  |
| 5GAL Bucket x2 | 5.94 |  |
| 4" Plastic Wing Nut Test Plug | 5.37 |  |
| 5GAL Leakproof Lid x3 | 5.04 |  |
| 3" Bladex Waste Val x2 | 19.98 |  |
|  |  |  |
| **Total:** | **150.37** |  |

\*\*Something to keep in mind in terms of dollars and cents is that the scale model price would be significantly reduced when mass-produced and if all supplies were purchased at wholesale price. \*\*

**Science behind the Madness:**

Within this concept of a self-containing, decomposing latrine system that could turn raw materials such as human feces into fuel; there is a lot of science behind the madness. Based on my research biomethane is described as: “a naturally occurring gas which is produced by the anaerobic digestion of organic matter such as dead animal and plant material, manure, sewage, organic waste, etc. (biomethane.org.uk).” Anaerobic digestion is described as “a group of processes by which microorganisms decompose biodegradable material in the absence of oxygen thus creating biomethane (Wikipedia)”. In addition, this anaerobic environment often creates a competitive environment for ‘non-infectious microorganisms to out compete pathogens’ (appropedia.org), these microorganisms can also be referred to as “methanogens”, and this is the bacterium that makes methane. As well if the ‘methanogens’ and pathogens are kept in an area that stays around 45-55 degrees Celsius, this will decrease the number of pathogens left in the slurry. If the bio-digester can be kept at such conditions there is another byproduct created from this process: bio-fertilizer. But the main product of this anaerobic process is biomethane, and “Since biomethane is chemically identical to natural gas, it can be used for the same applications as natural gas. It can be used for electricity generation, water heating, space heating, cooking as well as to fuel vehicles (biomethane.org.uk).”

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