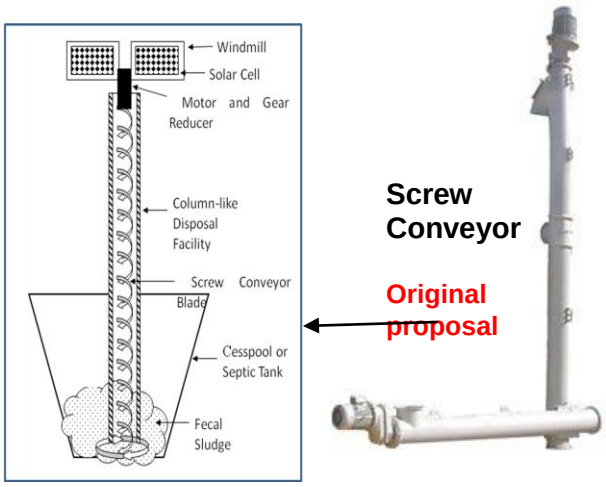
GCE Phase I Scientific Report

Our team was established for proposal development in Aug 2011. We begin with engineering pre-prototype testing immediately upon receipt of the Nov. 2011 grant. The key members of the team, including the principal investigator were formerly colleagues focusing on the mechanization of nuclear waste disposal.

Preprotoype Tests. Fecal Sludge Transmission By Screw Conveyor
Purpose :
1. Test the feasibility of lifting/transmission feacal sludge by screw conveyor.
2. Test the adaptability of the screw conveyor under impurity materials.
3. Test the adaptability of the screw conveyor under different moisture content.

Test conditions: (a)using cornmeal as artificial sludge, batches of 20 kg, the moisture content was 10%, 20%, 30%, 40%, 50%; (b)impurities: diameter 3 ~ 5cm stones in each batch of 2 kg +2 sanitary napkin,; (c) procressing device: LC-160 horizontal/ vertical screw conveyor. (maker: Hebei Star Chemical Machinery Manufacturers)



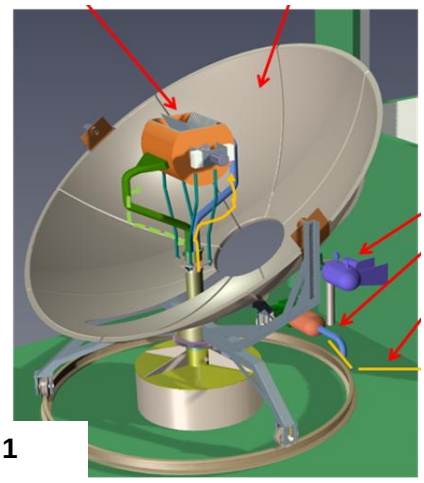
Test Resusts
1. Very good on loading and transmission sludge by screw conveyor LC-160.
2. The system is simple, good robustness, and has good adaptability to different impurities.
3. Can include consideragle amounts of water when sludge under high moisture content.

Conclusion: Test results support the idea of “vertical column evaporator”, in the Phase 2 the proposal.

Additional Challenges During The Project
During the course of this project, the team deepened our understanding of the fecal sludge disposal. Relative to the initial proposal a problem surfaced. The initial proposal focused on the solids of fecal sludge treatment without, in retrospect, adequately considering the pathogens of the human liquid waste components left behind and possibly overflowing from the pit or tank. In consideration of how to build the family solar toilet, it was necessary to consider how to process both the solid and the liquid components. In Phase 1, as we considered how a more complete approach to processing both the more solid and more liquid parts of the fecal waste, we realized that this also has implications for the initially proposed project of how to process the multiple family pit/tank in situ. These lessons are reflected in the Phase II proposal.

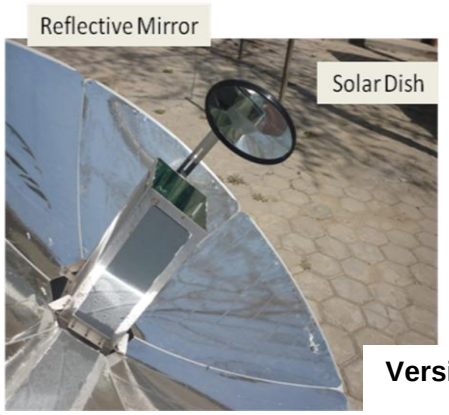
As demonstrated in Phase I, solar evaporation is a reliable and feasible way to processing human raw sewage waste, but evaporation is a high-energy-consuming process. Our engineering calculations show that the timely processing of 4 to 6 families of urine and other liquid liquid waste requires at least equivalent to **2Kw** electric power from the solar collector the waste processor. However, when considering the much higher of cost of photo voltaic cells, the solar-thermal approach is a much more cost effective way to evaporate the liquid componets and dry and sanitize the solid components in sunny locations.

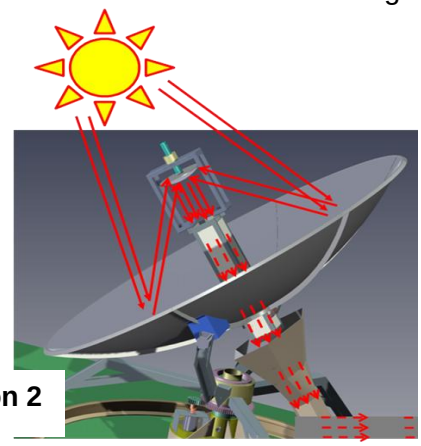
The initial prototype of the solar dryer was a sun-tracking, energy concentrated solar-dish which tested the feasibility of processing the waste at the focal point of the solar collector to use the full heating power of the sun with any heat transfer losses to the toilet. The design challenge was how to move fecal sludge and urine to the focus of solar-dish. The group tried three possible transporting/processing approaches. The first is by manual transport; the second is by mechanical transfer of the sludge container and the third is by moving the sludge by a pipeline, pump and valve subsystem. The experiments determined that the desired level of reliable operation of the system could not be achieved.



Version 1

The team next produced a second feasibility protoytpe from March to Apr, 2012 to move the light from the collector to the waste processor in the waterless toilet. We designed and fabricated a highway of reflecting mirrors, optical mirrors and light-guide tubes to channed the suns rays from the collector to the waterless toilet. In many ways, this provided an economic/reliable transfer of solar energy. We fabricated and tested a prototype based on this design. The inherent problem was the the inability of the optical components to withstaned the high temperature without resorting to much high cost optical components that exceeded the cost design targets.





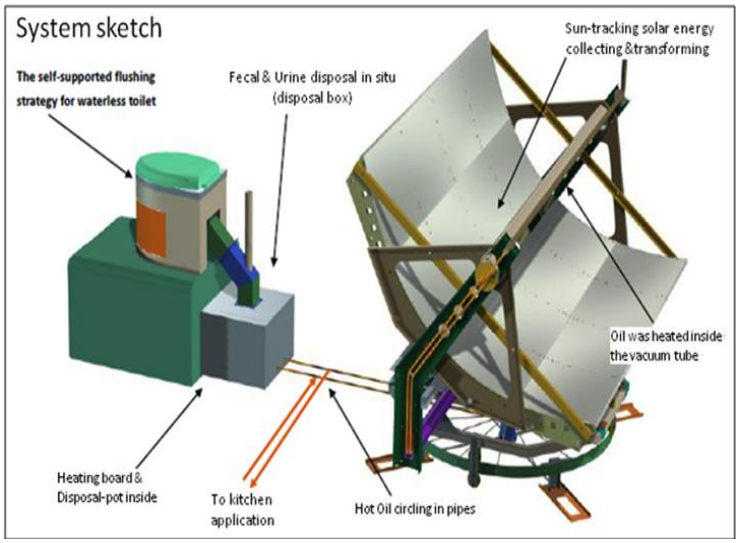
Version 2

The third and successful implementation uses circulating oil to efficiently transferred heat from the solar-energy collector to the disposal container using Solar Thermal Oil Recirculation (STOR). This testing proved that is sunny countries, a sun tracking solar collector can remotely dry and sanitize the raw sewage in quantities sufficient to meet the needs a family. After the heat is transferred from the solar collector to the waterless toilet the raw sewage processing steps are as follows: first, sludge is heated to at least 100C^{o}, causing evaporation, thereby dewatering the sludge; second, after the liquid portion is evaporated, the temperature of the remaining raw sewage in the evaporator rises above the 130^{o} - 150 C^{o} temperature range necessary to destroy the pathogens; and finally, the disposal chamber is replaced with an empty collector unit, then cleaned and made ready for re-use. The output of dry, sanitized, sludge provides a disinfected organic fertilizer.
The waterless toilet was designed with a system to recover the evaporated liquids by distillation and reuse this water for waterless toilet cleaning purposes. The solution employed a high-pressure car-

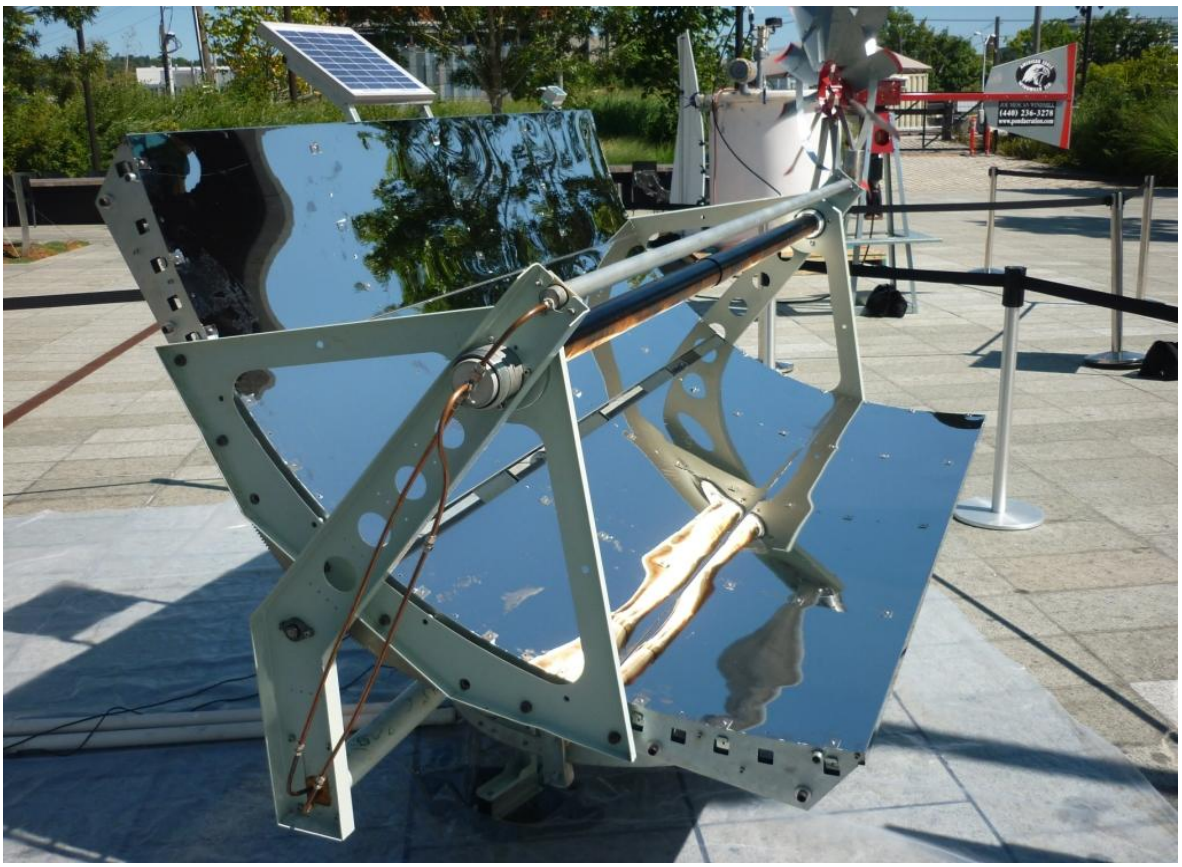
washing pump to provide 100 PSI pressure to blast away fecal reminants in the bown using small amounts of water recovered from the raw sewage by distillation.

The solar collector approach taken in this waterless toilet also provides as as a side for benefit, a heating plate for water purification and cooking. It is possible to build a larger solar collector i with excess heating capacity beyond the needs of the waterless toilet for drying and sterilization. The team demonstrated that the excess heat produced by the solar collector can be used for:

1. Boiling impure water to make the drinking water safe.
2. Distilling impure water to both make the water both safe but also t orderless and tasteless.
3. Cooking in sunny area which are lacking in coding fuels is an additional benefit in regions where fuel for cooking is in short supply.



The marginal costs of adding these features are relatively low compared to the expense of the solar collector and optional automatic tracking.



The prototype demonstrated on the " Reinvent the Toilet Fair" Aug 2012.

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Solar collector used to power hotplate for cooking or water purification

Distilled water from the liquid part of the fecal sludge used to clean the toilet bowl using a pressurizing pump.