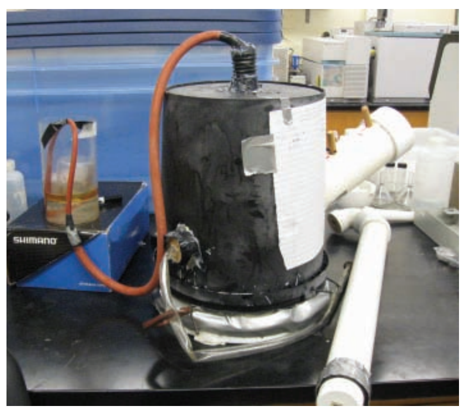
Guatemala

Students' Biodigesters Close The Loop

With a simple device, quality of life can be exponentially improved in developing countries.

Andrea Fox



Bench-scale biodigesters are made from PVC pipe, 5-gallon paint buckets, 5-liter water bottles, balloons and hoses.

"MOST of the world cooks on wood," says Salem State University's Christine MacTaylor, PhD, but that wood is both scarce in many places and can be a major source of pollution when burned. The silver bullet for this Massachusetts-based chemist inspired to combat poverty in developing countries is to provide people in arid or deforested regions with an energy substitute — "to keep them from having to need something they don't have," she explains. That silver bullet has taken the form of developing anaerobic digesters — aka biodigesters — at a cost and scale appropriate to the areas where they are needed.

Biodigesters are inexpensive, simple systems that not only manage animal and food wastes but produce a clean-burning fuel, nutrient-rich fertilizer and can even provide light to read by. Their potential has garnered the growing interest of both college professors and students in engineering, chemistry and interdisciplinary programs focused on sustainability.

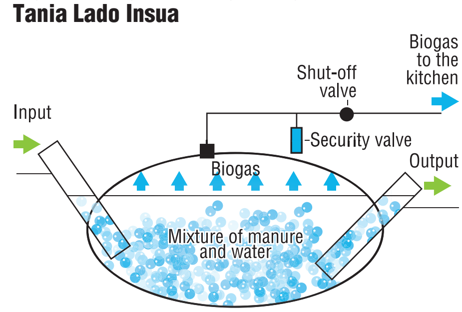
One project at the University of Rhode Island (URI) involved designing and building a three-stage-6-meter in diameter by 7-meter-long plug flow reactor digester in San Mateo Ixtatán, Guatemala, as part of a pilot test in May 2010. The digester will help a high school and its new farm produce light and energy for the farm's kitchen, to be built in August 2011. "The community relies heavily on wood for energy," says Vinka Oyanedel-Craver, URI assistant professor and project leader, noting that 40 years ago there was a thriving jungle in this region. "But there is nothing now," she says.

Start-Up Snafus, Community Acceptance

Working in the field as well as a classroom lab setting provides challenges to developing viable prototypes and working reactors. (Figure 1 shows one student's design.) Some of Oyanedel-Craver's students may have understood the methane production process after careful review of a five-reactor project by Ohio State University in Costa Rica, but they were unaware of construction challenges. When they arrived in Guatemala, they thought their biodigester would take a few days to build, she explains. It required more than a week due to the climate, hillside topography and wet, clay soils replete with large, heavy stones. The students had to figure out how to reduce runoff and build a drainage system.

Start-up of the URI anaerobic biodigester, which cost less than $100, was slower than normal due to rainy weather and a lack of manure, Oyanedel-Craver says. The three-stage reactor that was installed is designed to treat 10 to 15 pounds of manure/day, which the farm's cow, two to three pigs and 10 to 30 chickens are intended to supply, for an output of 700 to 800 liters of biogas per day. However the farm did not acquire pigs until late in 2010, and teachers

Figure 1. Digester diagram by URI Student Tania Lado Insua



A 6-meter in diameter reactor is made from $100 worth of polyethylene and other materials purchased in San Mateo. A PVC fitting connects the biodigester to a gas bag.

and students had to forage fields collecting stray manure. Not long after Oyanedel-Craver and her students left Guatemala, the biodigester became clogged. "They weren't mixing well enough to make a slurry," she says, but the reactor had initially produced gas.

In San Mateo Ixtatán, development partner Asociación Inhat was skeptical about the system. Acceptance of biodigestion "will depend how the community reacts to the technology," explains Oyanedel-Craver. "It's so new to them, it's hard to predict. They didn't know you could make energy from animal poop. They thought it was too good to be true."

However, once the community literally saw the light attached to the gas bag illuminated, they understood that "as long as they have animals, they will have a continuous source of gas," she says, adding that the community also quickly grasped the value of the organic fertilizer by-product. "At our small demonstration farm, we would use about 50 pounds of chemical fertilizer that cost about $16 on our vegetable garden," says Elias Alonzo, director of Asociación Inhat. "But now we can use liquid organic fertilizer that the biodigester produces as many times as we need using local resources that otherwise would just go to waste. The other amazing thing about the biodigester is the gas it produces that we can use to cook."

The win-win of the technology in today's resource-aware world is perhaps why students are more interested in biodigester projects than their predecessors. "Before the biodigester, crops were grown to become food for animals and humans, while firewood was brought to the farm to help prepare food," explains URI student Colleen Grinham. "Nothing was being reused, and materials were constantly being introduced and leaving the environment. Now, with the biodigester, crops are produced to feed the animals, which produce waste to 'feed' the biodigester, which produces biogas for cooking and heating and also fertilizer to produce better crops. It is incredible how this simple device could not only increase the quality of life for people in San Mateo Ixtatán, but also create a stable and sustainable producer of food and fuel."

Biodigesters For Any Home

Salem State University's MacTaylor assigned her students to construct biodigesters for under $50. "They're made from things we can get at any hardware store," she says. MacTaylor was following an example built by agronomist Gerry Baron. In in the Philippines, Baron constructed an in-ground 2 m^3 digester, which produces a 60 percent biogas yield, or 1 m^3 of biogas daily, when fed 100 liters of poultry manure. The student digesters are designed to compost food scraps — mostly cruciferous vegetables.

"We are trying to make a biodigester that can fit in any home or apartment and hope that it might make enough methane to cook one or two meals a day," she explains. "It's the most gas produced for the least amount of money."

Marketability may require a biodigester that could be used indoors or out, but there are odor and safety issues, MacTaylor adds, so ideally methane would be produced outside and then piped in. The professor is also interested in working on a thermocoupling mechanism — a link that would capture and produce voltage — into future models. The ability to charge an LED or cellular telephone on an apartment-sized biodigester could be a great value-added feature.

The assignment to build and operate bench-scale biodigesters in the university lab ran into a few snags. "We started the project last year and discovered it takes longer for methane-producing bacteria to grow than we could fit into one semester," MacTaylor says, so this year's students started in the fall. It became apparent over the past year that a clear rather than opaque container is preferred for monitoring progress of bacteria growth, that placement of the feeding tube below the level of food improves decomposition and that sizing is a critical factor. The students' research hasn't yet concluded whether a 5-gallon countertop biodigester will produce enough gas to cook a meal. For example, Baron's 2 m^3 digester produces enough gas to cook just three meals, so SSU students have just built a second set of biodigester units using 22-gallon toters.

The countertop versions should produce methane by the end of this semester, notes MacTaylor, adding that next year students will attach burner heads and actually test methane combustion. "If we are successful in the next couple of years, I would plan to first try and implement these — in Appalachia perhaps — before attempting to show people overseas how to build," says MacTaylor. ■

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Reprinted From:
April, 2011
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