Engineer builds low-cost device to purify human waste, make compost and generate electricity

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(Phys.org) -- Caitlyn Shea Butler, a civil engineering professor at the University of Massachusetts Amherst, has designed and is now field-testing a new "green latrine" that purifies human waste, turning it into compost for farming and generating electricity.Her multipurpose invention is called a "Microbial Fuel Cell Latrine."

Butler belives her inexpensive green latrine can be deployed throughout places such as rural Africa, transforming the way human waste is treated in areas where sanitation facilities are poor or nonexistent. At the same time, the device can play a key role in preventing waterborne diseases, including diarrhea.

"You get a lot out of this system," says Butler. "The latrine produces electricity. It makes compost. And you protect the ground water source. So you get a lot back for a small investment."

Butler traveled to Ghana in May to install a pilot version of her device. Working with graduate students Cynthia Castro and Joe Goodwill, collaborators Mark Henderson and Brad Rogers from Arizona State University, and residents of thesmall village of Agona Nyakrom, they installed the first working model of her Microbial Fuel Cell Latrine.

She says the pilot model can immediately address two issues faced by the village. First, when human waste leaches into underground water, deadly pathogens that cause waterborne diseases such as diarrhea spread throughout the aquifer. High nitrogen concentrations contained in the waste can also damage healthy water systems as well as cause nitrate poisoning in infants and the elderly. Butler's microbial latrine prevents that from happening.

The second problem is that many rural areas of Africa have limited electricity, and Butler's fuel cell would generate enough electricity to power a light within the latrine, thus allowing villagers access throughout the night.

"This is a centralized resource that will benefit the whole community," says Butler.

Butler's latrine works like a battery. It has an anode and a cathode and is similar to a fuel cell where a fuel, for example hydrogen, is oxidized at the anode, and an oxidant, such as oxygen, is reduced at the cathode. In this case, the organic waste matter is the fuel and nitrate is the oxidant. After solid wastes are first filtered in a composting chamber, dissolved waste organic matter is oxidized in an anode chamber. The oxidation of organic matter is assisted by bacteria on the anode surface and uses the anode as an electron acceptor to complete their metabolic reaction. Electrons released in this biological process are conveyed through a load-bearing circuit, producing electricity, to the cathode compartment. There a different community of bacteria uses the cathode as an electron donor, capturing the energy from the electrons, to reduce harmful nitrates in the waste stream.

The primary nitrogen compound found in human waste is ammonium, which can be broken down by oxidation, or nitrification. In Butler's latrine, nitrification takes place thanks to bacteria living in an intermediate chamber that separates the anode and cathode chambers. The result is effluent water that is quite low in organic matter and nutrients, minimizing pathogen persistence in the environment.

Butler says, “My research objectives focus on developing energy-efficient treatment strategies for both water and wastewater treatment. I examine bioelectrochemical systems where biofilms, capable of using either an anode as an electron acceptor or cathode as an electron donor, remediate environmental pollutants and concurrently produce electricity.”

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Provided by University of Massachusetts Amherst