



(Evan

Richman/Globe Staff file 2000) The Deer Island facility in Boston Harbor processes the city's waste and turns the solids into commercial fertilizer, but advocates say the future will require a far different approach than even modern sewer systems.

## Waste? Not

**We all produce a rich resource in our homes and then spend millions of dollars to throw it away. A new movement says there are smarter ways to think about waste.**

By Rebecca Tuhus-Dubrow | July 13, 2008

IN A WORLD of rapidly diminishing resources, there's one we tend to overlook. It's easy to produce and extremely abundant. But instead of viewing it as an embarrassment of riches, we're more likely to see it as just an embarrassment.

This neglected treasure is human waste. Urine is rich in nitrogen, potassium, and phosphorus, the three main ingredients in artificial fertilizer. Feces contains these nutrients, too, in smaller doses, and the methane it produces can be harnessed as biogas, a green energy source.

Yet in most cultures, understandably, the first impulse is not to use waste wisely, but to get rid of it as quickly as possible. In many rural, undeveloped areas, people simply "go" in the bush, or by the closest river. In advanced industrialized societies, we flush it away.

Both methods - and several others between the extremes - pose problems that grow more conspicuous every day. As the developing world has grown more crowded and urban, the lack of adequate sanitation has become a public health crisis. In America and other developed countries, the system works much more smoothly, but uses enormous quantities of clean water - about 4,000 gallons per person each year - and requires massive amounts of energy and money to treat the resulting sewage.

But now a growing global movement aims to make sanitation more sustainable by changing how both rich and poor countries think about human waste - recasting it as a valuable resource that is most costly when thrown away. Following a philosophy known as ecological sanitation, or "ecosan," and fueled by a convergence of factors - the rising prices of energy and artificial fertilizer, increasing worries about food security, and concern for the environment - the push to reform sanitation has gained currency around the world, driving innovations from toilet design to farming practices. And some sanitation reformers say they

are even making headway into the most vexing question: How to get people to see promise in a substance they are taught from birth to find revolting.

"There's been a lot of resistance and disbelief that anything like this can work," says Mayling Simpson-Hebert, a technical adviser with Catholic Relief Services in East Africa. "That seems to be changing."

Simpson-Hebert has helped to introduce a toilet called the arborloo - in which a fruit tree seedling is planted in a waste-filled pit - to thousands of Ethiopian farmers in the past few years. Numerous other projects are underway in the rest of the developing world. And the idea has started to gain traction in the developed world as well. In Europe, recent years have seen the advent of "urine diversion" toilets, which separate the two kinds of waste in order to treat it more efficiently, among other benefits. Locally, a private school in Weston has installed flushless compost toilets manufactured by Clivus Multrum, a company based in Lawrence. And several European pilot projects have begun to experiment with vacuum-biogas toilets, which require very little water and turn waste into energy.

Not everyone shares the enthusiasm for these sanitation technologies. Skeptics point to the cost, health concerns, and challenge of changing deeply ingrained habits and beliefs. Depending on the particular kind of system, the changes could entail a different experience of the toilet, or a different attitude toward the waste, or both.

For some proponents of sanitation reform in developed countries, that's part of the point: changing everyday behavior is going to be key to solving our ecological crises. According to Arno Rosemarin, research and communications manager at the Stockholm Environment Institute, our current "flush and forget" system makes it too easy to ignore the repercussions of waste disposal. If we are going to make meaningful changes in our environmental impact, the reasoning goes, perhaps we should start by thinking differently about the emissions that we ourselves produce.

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The idea of recycling our feces and urine may seem surprising, and perhaps disgusting, but the concept is hardly new. China and Japan have long traditions of re-using human waste as fertilizer. Even in England, as recently as the 19th century, "nightmen" would take human waste from backyards to sell to farmers.

But that was before the British "sanitation revolution." Exactly 150 years ago this summer, the river Thames in London overflowed with human waste in what was known as the Great Stink, forcing Parliament, located on the banks of the Thames, to take action. Sewers were subsequently installed, eventually resulting in major public health advances.

The flush toilet and its infrastructure have since become standard throughout the developed world. Excreta flow out of sight to a sewer system, and then to a waste treatment plant. In more remote areas, the sewage goes to nearby septic tanks that must be periodically emptied. The system's benefits are obvious, but it also has downsides that are growing increasingly apparent.

Annually, each of us produces about 13 gallons of feces and 130 gallons of urine, which is instantly diluted into the 4,000 gallons we use to flush it. This large quantity of contaminated liquid further mixes with "greywater," the water from the laundry, shower, and sink, tripling or quadrupling the amount of water that must be treated as sewage in energy-intensive plants. In effect, the system takes a relatively small amount of pathogenic material - primarily the feces - and taints enormous amounts of water with it. Especially in regions struggling with freshwater scarcity, many observers have come to see this system as highly inefficient. "It's a totally insane idea," says Rosemarin.

In this model, it's not only water that's wasted, critics say - it's also the valuable nutrients in the feces and urine, notably phosphorous. Global fertilizer prices have tripled in the last year, partly due to a shortage of phosphorus, which some see as a looming crisis. Against this background, some argue that it would be folly not to capitalize on the plentiful phosphorus in human waste. In the same vein, the methane it generates has the potential to provide cheap, renewable energy.

Rose George, author of a forthcoming book about sanitation, "The Big Necessity," says of the conventional system, "It was a solution 150 years ago and it was a very good one, but it should evolve."

Over the past couple of decades, some measures have already begun to exploit the value of waste and improve the system's efficiency. It has become common for treatment plants to convert some of the

methane generated by sludge into biogas to partially power their own plants. Low-flush toilets and waterless urinals are small steps to conserve water. And the practice of using treated sludge - renamed "biosolids" - as chemical fertilizer has become customary in parts of the developed world. In the United States, according to the Environmental Protection Agency, about 50 percent of all biosolids are being recycled to land. The Massachusetts Water Resources Authority turns all of its sludge into fertilizer, some of which it sells commercially through a contractor and some of which it gives to communities.

But ecosan advocates assail this practice as unsustainable and unsafe. Under the current system, household waste mixes with industrial waste, including toxic materials. Although the EPA has issued treatment regulations, and the MWRA defends the safety of its fertilizer, there are concerns about the impact of sludge-derived products on soil and human health.

The most radical visionaries of this movement would apply the same principles to sanitation that we have begun to apply to other garbage in our homes. Just as we separate plastic, cardboard, and newspaper, says Rosemarin, we should separate urine, feces, and greywater.

As a first step down this road, some companies are producing new types of toilets. One idea, pioneered in Sweden, is known as urine diversion. The basic concept is that the toilet has two receptacles for the different kinds of waste. "Don't mix what God separates," says Steven Sugden, a research fellow at the London School of Hygiene and Tropical Medicine who has worked on sanitation projects in Africa.

The benefits of taking urine out of the waste stream are clear: Urine makes up less than 1 percent of all waste water in developed countries, but contains a huge proportion of the nitrogen and phosphorus. Those nutrients are essential to agriculture but harmful in water bodies, and removing them is the most energy-intensive part of treating waste water. And since urine is almost sterile, it can be used as fertilizer with little to no treatment.

In Europe and Australia, there have been numerous experiments with different kinds of urine-diversion toilets. The Swedish company Roediger sells one called the NoMix, with a back compartment that functions like a standard flush toilet and a front compartment for urine - essentially a conventional toilet with a built-in urinal. First developed in the 1990s, these and other urine-diversion toilets have gradually begun to be used in Sweden, and a few municipalities have taken responsibility for collecting the urine.

Vacuum toilets, much like those on airplanes, are also gaining currency. These typically require less than a quart of water per flush. A promising innovation is the vacuum-biogas toilet, in which waste is sucked into a vacuum sewer system, and then transferred to a local biogas plant. Recent pilot projects have tried this technology in settlements in Holland and Germany. Hamburg is in the planning phase for a project that would give vacuum-biogas toilets to 2,000 houses, according to Ralf Otterpohl, director of that city's Institute of Wastewater Management and Water Protection. He says the water utility is considering converting the city to this system over the next 50 years.

Perhaps the simplest mechanism is a compost toilet, such as those made by Clivus Multrum. The toilets look normal from the outside, but inside, the waste drops into a dark hole. A ventilation system pulls air down to prevent odor. In the space below, the liquid and solid waste separate. The liquid can be used immediately as fertilizer, while the solid waste is stored for at least one year - with monthly raking and the addition of pine shavings - and then is ready to be harvested as compost.

"It works like your garden compost pile," says Don Mills, the company's sales director. "It's low-tech, it's no-tech. We're just employing a process that is one of the essential processes in nature."

Mills says the company sells mainly to parks, green buildings, and nature centers. A private school in Weston, the Cambridge School, recently installed the toilets in its new green building. Last year, similar Clivus toilets were installed at the Bronx Zoo, avoiding the need to build a large septic system or expensive sewerage, and saving over a million gallons of water a year.

There are, however, obstacles to widespread implementation of unorthodox toilets. Space limitations make compost toilets infeasible in most urban areas. Vacuum toilets require a different plumbing system. And there may be psychological barriers to changing habits in the bathroom.

For urine diversion, men would have to sit to urinate toward the front of the toilet. Although its proponents offer assurances that it's easy for women to use, some critics question that assertion. "For a guy, that's not too technically challenging," says Eddy Perez, a sanitation specialist at the World Bank. "But you've got

women of different sizes. It's just pretty complicated from a human behavior, human physiology perspective." Aiming could also pose problems for children.

Transforming the sanitation system in the developed world "can be done," says author Rose George, "but it would basically require revolution."

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Partly due to the lack of infrastructure, it's in the developing world where the biggest changes have so far taken place. The problems there are quite different. Due to the lack of proper sanitation facilities, diseases caused by ingested fecal matter are rampant; diarrhea, for example, kills more children than AIDS. But the advantages of the ecosan approach are similar, because a well-designed system allows people to harvest the benefits of waste. And given the poverty and food insecurity, these benefits are often more acutely felt.

A popular kind of toilet is called the fossa alterna, in which two 3-meter-deep pit latrines are dug side by side. Once one is filled, after about a year, it is sealed off, and the other one is used. Eventually, the waste in the first pit will be ready to be retrieved - after time, the pathogens die off - and used or sold as fertilizer for crops. Some sanitation experts worry about health risks: If the waste is touched too soon, the toilet could exacerbate the problems it's intended to help solve. But a growing number of rural residents in Zimbabwe, Malawi, and other countries have started to prize the product they reap.

A more sophisticated system, used most often in urban areas, allows groups of families, as well as schools, to produce their own biogas. To create biogas, vegetable scraps and grass and human excreta are collected in a pit. They produce methane, which is captured in a tube and channeled to a kitchen stove or shower. The UN is involved in such projects in India and Senegal, among other places.

One of the most successful efforts has unfolded in Ethiopia. Starting in 2005, Catholic Relief Services introduced a toilet called the arborloo to extremely poor Ethiopian farmers. "All of the other toilet options we had introduced over the years had failed," says Mayling Simpson-Hebert.

The arborloo is a shallow pit latrine that costs only \$5. When it's filled, the farmer plants a fruit tree seedling. The farmers are given two seedlings, one to plant in the arborloo, and another as a control. The comparison enables them to observe that the one in the arborloo grows much faster and produces more fruit. The farmers can eat the fruit and sell it on the market. Today more than 26,000 farmers are using these toilets, according to Simpson-Hebert, with strong support from the Ethiopian government.

This simple device has brought about the kind of change in thinking that reformers hope will eventually take root in the developed world.

"Some of our farmers say, 'We used to think poop was dirty, but now it's our gold,' " says Simpson-Hebert. "They won't let their children defecate in the open. They say, 'Go put your gold in the toilet.' "

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