

## Meet the Peecyclers. Their Idea to Help Farmers Is No. 1.

A shortage of chemical fertilizer, worsened by the war in Ukraine, has growers desperate. It just so happens that human urine has the very nutrients that crops need.



By Catrin Einhorn

For this article Catrin Einhorn traveled to Vermont, where she saw many different kinds of toilets.

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BRATTLEBORO, Vt. — When Kate Lucy saw a poster in town inviting people to learn about something known as peecycling, she was mystified. “Why would someone pee in a jug and save it?” she wondered. “It sounds like such a wacky idea.”

She had to work the evening of the information session, so she sent her husband, Jon Sellers, to assuage her curiosity. He came home with a jug and funnel.

Human urine, Mr. Sellers learned that night seven years ago, is full of the same nutrients that plants need to flourish. It has a lot more, in fact, than Number Two, with almost none of the pathogens. Farmers typically apply those nutrients — nitrogen, phosphorus and potassium — to crops in the form of chemical fertilizers. But that comes with a high environmental cost from fossil fuels and mining.

The local nonprofit group that ran the session, the Rich Earth Institute, was working on a more sustainable approach: Plants feed us, we feed them.

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Efforts like these are increasingly urgent, experts say. Russia’s invasion of Ukraine has worsened a worldwide fertilizer shortage that’s driving farmers to desperation and threatening food supplies. Scientists also warn that feeding a growing global population in a world of climate change will only get more difficult.

Now, more than a thousand gallons of donated urine later, Ms. Lucy and her husband are part of a global movement that seeks to address a slew of challenges — including food security, water scarcity and inadequate sanitation — by not wasting our waste.

At first, collecting their urine in a jug was “a little sloshy,” Ms. Lucy said. But she was a nurse and he was a preschool teacher; pee didn’t scare them. They went from dropping off a couple of containers every week or so at an organizer’s home to installing large tanks at their own house that get professionally pumped out.



Kate Lucy and Jon Sellers at home with their children. At first, collecting urine was “a little sloshy,” Ms. Lucy said. John Tully for The New York Times





Arthur Davis, a researcher and program director at the Rich Earth Institute, prepared a urine collection truck for its rounds in May. John Tully for The New York Times

Now, Ms. Lucy feels a pang of regret when she uses a regular toilet. “We make this amazing fertilizer with our bodies, and then we flush it away with gallons of another precious resource,” Ms. Lucy said. “That’s really wild to think about.”

Toilets, in fact, are by far the largest source of water use inside homes, according to the Environmental Protection Agency. Wiser management could save vast amounts of water, an urgent need as climate change worsens drought in places like the American West.

It could also help with another profound problem: Inadequate sanitation systems — including leaky septic tanks and aging wastewater infrastructure — overload rivers, lakes and coastal waters with nutrients from urine. Runoff from chemical fertilizer makes it worse. The result is algal blooms that trigger mass die offs of animals and other plants.

In one dramatic example, manatees in the Indian River Lagoon in Florida are starving to death after sewage-fueled algal blooms destroyed the sea grass they depend on.

“The urban environments and aquatic environments become hideously polluted while the rural environments are depleted of what they need,” said Rebecca Nelson, a professor of plant science and global development at Cornell University.

Beyond the practical benefits of turning urine into fertilizer, some are also drawn to a transformative idea behind the endeavor. By reusing something once flushed away, they say, they are taking a revolutionary step toward tackling the biodiversity and climate crises: Moving away from a system that constantly extracts and discards, toward a more circular economy that reuses and recycles in a continuous loop.

Chemical fertilizer is far from sustainable. The commercial production of ammonia, which is mainly used for fertilizer, uses fossil fuels in two ways. First, as the source of hydrogen, which is needed for the chemical process that converts nitrogen from the air into ammonia, and second as fuel to generate the intense heat required. By one estimate, ammonia manufacturing contributes 1 to 2 percent of global carbon dioxide emissions. Phosphorus, another key nutrient, is mined from rock, with an ever dwindling supply.

Across the Atlantic, in rural Niger, another study of urine fertilization was designed to address a more local problem: How could female farmers increase poor crop yields? Often relegated to the fields farthest from town, the women struggled to find or transport enough animal manure to replenish their soils. Chemical fertilizer was far too expensive.

A team including Aminou Ali, director of the Federation of Maradi Farmers' Unions in south-central Niger, guessed that the comparatively fertile fields closer to people's homes were getting a boost from people relieving themselves outside. They consulted with medical doctors and religious leaders about whether it would be OK to try fertilizing with urine, and got a green light.

"So we said, let us test that hypothesis," Mr. Ali recalled.

It took some convincing, but the first year, 2013, they had 27 volunteers who collected urine in jugs and applied it to plants along with animal manure; no one was willing to risk their harvest on pee alone.



A program in southern Niger began as a way to help female farmers who could not afford chemical fertilizer. Will Miller/McKnight Collaborative Crop Research Program





Researchers found that urine, either with animal manure or alone, increased yields of some crops by about 30 percent. Will Miller/McKnight Collaborative Crop Research Program

“The results we got were very fantastic,” Mr. Ali said. The next year, about 100 more women were fertilizing with it, then 1,000. His team’s research ultimately found that urine, either with animal manure or alone, increased yields of pearl millet, the staple crop, by about 30 percent. That could mean more food for a family, or the ability to sell their surplus at market and get cash for other necessities.

It was taboo for some women to use the word urine, so they renamed it oga, which means “boss” in the Igbo language.

To pasteurize the pee, it stays in the jug for at least two months before the farmer applies it, plant by plant. The urine is used at full strength if the ground is wet, or, if it’s dry, diluted 1:1 with water so the nutrients don’t burn the crops. Scarves or masks are encouraged, to help with the smell.

At first, the men were skeptical, said Hannatou Moussa, an agronomist who works with Mr. Ali on the project. But the results spoke for themselves, and soon men started saving their urine, too.

“It’s become now a competition in the house,” Dr. Moussa said, with each parent vying for extra urine by trying to persuade the children to use their container. Wising up to the dynamic, some kids have started demanding money or candy in exchange for their services, she added.

The kids aren’t the only ones who see economic potential. Some entrepreneurial young farmers have taken to collecting, storing and selling urine, Mr. Ali said, and the price has spiked in the last couple years, from about \$1 for 25 liters to \$6.

“You can go pick up your urine like you’re picking up a gallon of water or a gallon of fuel,” Mr. Ali said.

So far, the research on harvesting and packaging the nutrients in urine isn’t advanced enough to solve the current fertilizer crisis. Collecting urine at scale would, for example, require transformative changes to plumbing infrastructure.

Then there’s the ick factor, which peecycling supporters confront head on.



“Human waste is already being used to fertilize foods you find in the grocery store,” said Kim Nace, a co-founder of the Rich Earth Institute, which collects the urine of some 200 volunteers in Vermont, including Ms. Lucy’s, for research and application on a handful of local farms.

The stuff being used already is treated leftovers from wastewater plants, known as biosolids, which contain only a fraction of urine’s nutrients. It can also be contaminated by potentially harmful chemicals from industrial sources and households.

Urine, Ms. Nace asserted, is a much better option.

So, every spring, in the hills around the Rich Earth Institute, a truck with a license plate reading “P4Farms” delivers the pasteurized goods.



Kim Nace, co-founder of Rich Earth Institute, with a collection tank outside her home in Brattleboro. John Tully for The New York Times





A farmer in Dummerston, Vt., towed an applicator filled with pasteurized urine. John Tully for The New York Times

“We see very strong results from the urine,” said Noah Hoskins, who applies it to hayfields at the Bunker Farm in Dummerston, where he raises cows, pigs, chickens and turkeys. He said he wished the Rich Earth Institute had more pee to give. “We’re in a moment where chemical fertilizer has more than doubled in price and is really representing a part of our system that is way out of our control.”

One of the biggest problems, though, is that it doesn’t make environmental or economic sense to truck urine, which is mostly water, from cities to distant farmlands.

To address that, the Rich Earth Institute is working with the University of Michigan on a process to make a sanitized pee concentrate. And at Cornell, inspired by the efforts in Niger, Dr. Nelson and colleagues are trying to bind urine’s nutrients onto biochar, a kind of charcoal, made, in this case, from feces. (It’s important to not to forget about the poop, Dr. Nelson noted, because it contributes carbon, another important part of healthy soil, along with smaller amounts of phosphorus, potassium and nitrogen.)

Similar experiments and pilot projects are underway around the world. In Cape Town, South Africa, scientists are finding new ways to harvest urine’s nutrients and reuse the rest. In Paris, officials plan to install pee-diverting toilets in 600 new apartments, treat the urine and use it for the city’s tree nurseries and green spaces.

Karthish Manthiram, a professor of chemistry and chemical engineering at the California Institute of Technology, said he was interested to see where the efforts would lead. His own lab is trying to develop a clean process to synthesize nitrogen from the air. “These are all methods that need to be pursued because it’s too early right now to tell what’s going to win out,” Dr. Manthiram said.

What feels certain, he said, is that the current methods of acquiring fertilizer will be replaced, because they are so unsustainable.

Peecyclers in Vermont describe a personal benefit from their work: A sense of gratification thinking about their own body’s nutrients helping to heal, instead of hurt, the earth.

“Hashtag PeeTheChange,” quipped Julia Cavicchi, who directs education at the Rich Earth Institute. “Puns aren’t the only reason I’m in this field,” she added, “but it’s definitely a perk.”