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Coastal Science and Societies

Medications and other manmade substances make their way through sewage systems and contaminate rivers and oceans.
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Sewage Rehab

After decades of work, green chemistry may be the answer to polluted sewage.

by Erica Cirino
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Compounds that mimic or disrupt human hormones are showing up in freshwater ecosystems worldwide. This widespread pollution is causing the feminization of fish and amphibians, as well as the disruption of natural freshwater microbial communities. It's even making fish anxious. For people, living near to such polluted waterways is associated with an elevated risk of some cancers. The presence of hormones and hormone disruptors is not a new problem, but it's one that waste treatment experts have been struggling to solve. These compounds sneak through many conventional wastewater treatment systems. But they don't have to.

Terrence J. Collins has been working for decades on a technology to solve this pollution problem. Collins, a chemist at Carnegie Mellon University in Pittsburgh, Pennsylvania, has engineered enzymes that emulate those in the human liver. If used alongside traditional water treatment, these enzymes break down the harmful chemicals—including drugs—that are otherwise missed. But here's the thing: Collins developed and patented this technology, tetra-amido macrocyclic ligand (TAML) activators, nearly 30 years ago, long before worries about hormones in the water entered the public consciousness. He's honed the technology ever since, making it more effective than ever. No municipalities have bought into the technology yet, but it has been a runner-up for pilot programs in Europe and there is hope that a US-based program will be in the works soon.

In 1992, Collins successfully created his first water treatment enzymes. But support from the mainstream chemistry community studying wastewater treatment has been almost nonexistent, he says. The chemist suspects the lack of enthusiasm is for ideological—rather than technological—reasons. Collins is a green chemist.
Green chemistry, as a concept, was developed in part by John Peterson Myers, an academic and coauthor of the 1996 book *Our Stolen Future*, which is about endocrine disruptors and toxicant pollution in the urban environment. Green chemists focus on developing new chemicals and chemical processes that are Earth-friendly.

"The traditional chemical lobby opposes this kind of work, and universities are afraid to embrace this new way of thinking about chemistry because they fear their funding will be cut off from the chemical lobby," Collins says, adding that it's been very difficult for him to find academic funding for his research.

Industry insiders say one reason green chemistry has progressed in only fits and starts is that people are skeptical of a new technology that sounds too good to be true. Sean Palmer, a biomedical engineer and decontamination specialist in the United Kingdom, says he has long had trouble convincing others that Collins's novel technology is highly effective.

"I talk to wastewater treatment plant managers about TAML, and even show them live demos of the technology, and it seems like they can't wrap their heads around the fact that it really works, and that it works better, faster, more safely, and more cheaply than what's out there right now," Palmer says. TAML activators are green chemicals, producing no hazardous byproducts.

When combined with hydrogen peroxide, TAML activators act like liver enzymes, sparking chemical reactions that break down artificial hormones, pharmaceuticals, and illicit drugs into benign compounds, such as water and carbon dioxide.
TAML activators can't do everything, but neither can existing wastewater treatment technologies, Collins says. None can break down fluorinated compounds such as perfluorooctanoic acid, used to make Teflon; the common pesticide metaldehyde; or heavy metals.

Other wastewater treatment technologies do exist, some of which can help reduce the quantity of hormones and drugs that slip through processing. Two technologies—ozone and activated carbon—are in common use, and there are other experimental techniques in development. But TAML activators require less energy to run and are cheaper than these other treatments.

"It looks like TAML has a lot of promise," says Anne McElroy, an aquatic toxicologist at Stony Brook University in Stony Brook, New York. She supports use of green chemicals as a replacement for many hazardous chemicals to benefit human and environmental health, but says TAML may not be the silver bullet Collins suggests.

“Collins needs to tread carefully,” says McElroy. “He needs to ensure these catalysts are monitored for their toxicity, so they actually do not cause more harm to the environment.”

But after a 30-year struggle to solve what’s been an intractable sewage problem for communities around the globe, Collins is more than ready for the technology to prove itself.

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