Biosolids

THE CHALLENGE

In the United States alone, billions of gallons of water are used each day—flushed and rinsed down drains to be cleaned at water resource recovery treatment facilities. But once the water is clean, a different challenge remains: determining what to do with the solids that are removed during the treatment process. The resulting mixture is often a semi-solid blend of organic and inorganic materials, trace elements, chemicals, and even pathogens, so there is no across-the-board solution for handling the combinations of constituents that may be present.

Weighing in at more than seven million dry tons per year, the sheer volume of solids is something many facilities struggle to manage. Because they are often rich in nitrogen and phosphorus, many facilities have turned to land application. But before these solids can be used as fertilizer, they must undergo treatment to meet regulations, at which point they become known as biosolids. "Biosolids" refers to treated sewage sludge that meets the U.S. Environmental Protection Agency's (EPA) pollutant and pathogen requirements for land application and surface disposal. See EPA's Biosolids Program website for more information.

THE RESEARCH

Beginning in the 1980s, WRF emerged as an early leader in biosolids research. When the EPA released its standards for the disposal and use of sewage sludge a decade later, this research provided much needed guidance. Since that time, WRF has taken on more than 100 projects in this area, building a $20-million body of research. Topics include disposal, thickening and dewatering, treatment optimization, biosolids quality, beneficial use, risk assessment, and communication.

WRF realized that sound biosolids research requires involvement from a many participants and has built long-lasting relationships with partners like the EPA, the Water Environment Federation, the New York City Department of Environmental Protection, the California Association of Sanitation Agencies, the Northeast Biosolids and Residuals Association, and the Mid-Atlantic Biosolids Association.

Treatment and Management

Solids and residuals treatment and handling are big components of a treatment facility's budget, so making sure these processes are efficient and effective is a top priority. WRF has led efforts to improve treatment methods—from ways to drive down treatment costs and waste products to processes that create higher-quality products.

WRF is at the forefront of researching not only high-tech solutions, but also low-cost, low-tech methods that facilities can easily integrate into their current processes to meet class-A biosolids standards. In 2019, WRF published *High-Tech Analysis of Low-Tech Methods for Sustainable Class A Biosolids Production, Phase II* (NTRY11T15b/4947), which investigated pathogen and indicator organism inactivation in systems that rely on long-term storage of biosolids under different conditions. Based on pilot results, the research team found that one year of high-solids, long-term storage is sufficient for compliance with the Class A criteria for fecal coliform and human poliovirus,

SOLUTIONS IN THE FIELD: DC Water

In the early 2000s, the District of Columbia Water and Sewer Authority (DC Water) was at a crossroads: double down on existing biosolids technology at their Blue Plains plant, which needed millions of dollars in upgrades, or completely innovate their biosolids program. They chose to innovate—but they wanted to be sure they had the science to back it up. The ground-breaking process they developed was a result of a decade of research from five WRF-funded projects and a unique collaboration with Bucknell University and Brown and Caldwell.

Going live in 2015, DC Water invested $470M in the project to transform the way wastewater solids are processed and managed. It is the first installation of the Cambi™ thermal hydrolysis process in North America, and integrates a state-of-the-art dewatering facility, combustion gas turbines, and four 80-foot anaerobic digesters. The resulting savings more than pays for the cost of the project. DC Water has cut their biosolids production in half, boosted the quality of their biosolids above class A levels, lowered their carbon footprint, and are generating enough electricity to meet about a third of Blue Plain's energy needs.

but a subsequent air-drying phase is needed to meet the *Ascaris* ova equivalency standard.

Risk Assessment

When it comes to land application and disposal of biosolids, public health and environmental protection are the ultimate goals. Reducing potential impacts from trace organics and pathogens is key. WRF has been working to improve detection, monitoring, quantification, and treatment of these pollutants and to provide tools and information facility managers need to determine treatment effectiveness.

WRF's project, *Developing Exposure and Toxicity Data for Priority Trace Organics in Biosolids* (TOBI2R15/4867) studied three significant trace organic compounds: brominated diphenyl ethers (BDEs), azithromycin (AZ), and ciprofloxacin (CIP). Due to difficulties in measuring the BDEs in a biosolids-soil matrix and the expense of having these analyses done at a contract laboratory, additional laboratory and fields measures as well as risk assessments for the BDEs were not performed. The risk calculations for CIP and AZ suggest that biosolids application scenarios are without appreciable human and ecological risks. Pollutant concentration limits were determined to be 12 mg CIP/kg biosolids and 2.2 mg AZ/kg biosolids, which suggest that the majority of biosolids in the United States can be freely land applied without CIP and AZ load tracking requirements.

WRF has also advanced risk assessment of pathogenic activity in bacteria, viruses, and other microorganisms. Because accurate microbial detection hinges on proper sampling, WRF released early guidance on biosolids collection and handling in the field that is based on EPA-approved methods. Although sampling techniques previously had been verified in the lab, research showed that field practices varied. *Biosolids Quality Control and Quality Assurance Procedures: Guidance for Samplers* (04-HHE-7FG/1178), outlines consistent protocols, resulting in more reliable microbial measurements.

Following the application of biosolids to agricultural soils, plants may become contaminated by organic compounds in these solids. The degree of plant uptake depends on the physicochemical properties of the organic compound, as well as the fate (biodegradation, sorption, volatilization) within the biosolids-amended soil system and the transformation, metabolism, and sequestration of organic compounds in plant tissue. To more fully understand whether biosolids-borne organic compounds present risks to humans or the environment, in 2020 WRF published *Knowledge Gap Analysis for Plant Uptake Models* (TOBI3R17/4868). It provides an overview of the processes and pathways through which organic compounds in biosolids may enter plants, and a description of the parameters and processes commonly employed in conventional plant uptake models.

Communication

Building public trust and support for biosolids requires thoughtful, effective communication. As early as the 1990s, WRF began providing some of the first scientifically based guidance in this area—changing the way the water sector communicates about issues that cause public concern, like potential risks and odors, and opening a clear and transparent conversation.

In 2011, WRF released a suite of research that focuses on public perception, including *A Primer for Biosolids Professionals* (SRSK2R08a/1750) and several tools to help in the development of outreach programs in communities where biosolids are applied. Adapted from processes in place at health agencies and piloted at several water facilities, the research outlines how to design, conduct, and evaluate effective communication efforts.

A Protocol for the Surveillance and Investigation of the Concerns Reported by Neighbors of Land Application (08-HHE-5PP/1199),published in 2012, outlines an early approach for biosolids-related human health investigations that relies on public partnering. Pooling expertise from public health organizations, regulating agencies, conservation groups, community leaders, private citizens, academics, water facilities, and others, the process is designed for use by a broad base who may not have a public health background.It helps the public accurately describe and document complaints, which can then be used to track trends in health symptoms and other concerns.

Resource Recovery

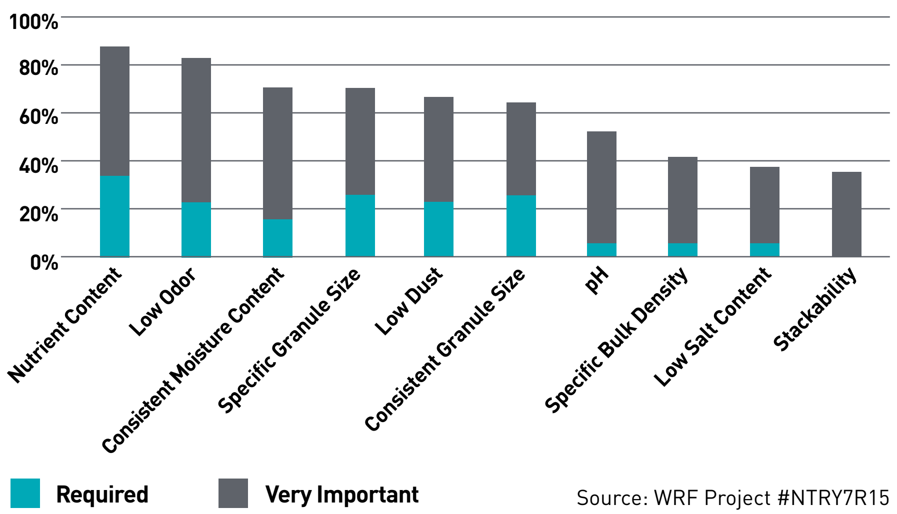
WRF is working to increase the quality of solids to open up new application options, as well as tapping into their potential as a clean, sustainable energy source.

Because higher quality biosolids have greater potential for use, WRF has been helping to define what it takes to meet the standards set in EPA's 40 CFR Part 503 regulation. Odor continues to be the most common reason for public complaints around land application. *High-Quality Biosolids for Wastewater* (NTRY7R15/4823) has already helped in this area, developing a method to measure odor concentration in relation to treatment methods, which can potentially be used to adjust treatment to get better results.

As stricter regulations drive water facilities to use increasingly energy-intense processes, WRF is helping to balance this need by harnessing the energy contained in biosolids. In 2010, WRF launched a research area dedicated to developing new opportunities for recovering resources from wastewater and solids, focusing on areas such as biogas production, co-generation of heat and energy, and thermal hydrolysis.

Co-Digestion of Organic Waste Products with Wastewater Solids (OWSO5R07a/1552) was among some of the leading research to test co-digestion at full-scale, shedding light on the amounts and types of organic waste that can safely be added to anaerobic digestion without disrupting systems. It also identifies the type of wastes that have a synergistic effect when added to biosolids, such as fats, oils, grease, and glycerol, creating a significant boost in biogas production. Additionally, *Developing Business Cases for Food*

WHAT ARE CUSTOMERS LOOKING FOR IN BIOSOLIDS PRODUCTS?



Source: WRF Project #NTRY7R15

Waste Co-Digestion at Water Resource Recovery Facilities (ENER19C17/4792) developed a framework for WRRFs to analyze the sustainability of co-digestion and create a business case for a co-digestion program.

The design and control of anaerobic processes is traditionally based on measurements such as chemical oxygen demand conversion efficiency, consumption of alkalinity, and gas composition and production rates. However, the recent movement from traditional wastewater treatment towards resource recovery has changed things. Energy recovery through intensified treatment such as thermal hydrolysis; co-digestion of feedstocks like fats, oils, grease, and food waste to enhance biogas production; continue to advance. These new processes and feedstocks are shifting towards novel and more complex anaerobic carbon conversion processes, which require a better understanding of the microbial communities, carbon conversion pathways, and kinetics. *Nationwide Meta-Omics Survey of Anaerobic Digestion and Fermentation Processes for Resource Recovery from Biosolids and Other Organics* (U1R15/4871), published in 2020, investigated lab, pilot- and full-scale anaerobic digestion and fermentation process configurations operated under different conditions and with different feedstocks. The project used a systems biology approach to explore the link between microbial structure-function and process performance on a common platform. This research will lead to better diagnoses of underlying issues in problematic bioreactors and smarter design of new wastewater and food waste treatment options.

Please refer to WRF's Resource Recovery topic overview for more in-depth information on nutrient recovery, resource recovery intensification, source-separated organic feedstock, and more.

WHAT'S NEXT?

In February 2020, WRF hosted the *Biosolids Research Summit* (5055) to identify priority research needs related to biosolids. Attendees set a new biosolids research agenda to address unanswered questions, re-examine the 40 CFR 503 regulations, demonstrate the latest technologies for solids treatment, and examine the fate of emerging contaminants (e.g., PFAS) in biosolids. This summit developed 11 project concepts for the multi-year research agenda.

Because PFAS are used in a wide variety of consumer care products, which are typically washed down drains, they are being found in wastewater treatment plant influent and effluent. And now, municipal wastewater effluents and biosolids are being viewed as potential pass-through sources of PFAS in the aquatic environment. During wastewater treatment, polyfluoroalkyl compounds (often called precursors) can degrade into perfluoroalkyl compounds. However, due to their chemical nature, these compounds are not efficiently removed during conventional wastewater and sludge treatment processes. Thus, the release of treated effluent as well as the widespread land application of biosolids provides an opportunity for the re-release of PFAS into receiving environments. Two projects are currently underway to explore these implications: *Occurrence of PFAS Compounds in U.S. Wastewater Treatment Plants* (5031) and *Investigation of Alternative Management Strategies to Prevent PFAS from Entering Drinking Water Supplies and Wastewater* (5082).

In September 2021, WRF won a $1.5M grant from the EPA's National Priorities program for a project entitled, *Unregulated Organic Chemicals in Biosolids: Prioritization, Fate, and Risk Evaluation for Land Applications* (5136–5139)). Despite many potential benefits, biosolids contain numerous unregulated organic chemicals (UOCs) that may detract from their beneficial use. This suite of projects will prioritize UOCs in biosolids based on their occurrence, mobility, persistence, and bioaccumulation.

According to NEBRA, management of wastewater solids can account for up to 50% of a treatment facility's operating costs. WRF research is helping to improve dewatering, increase digester-loading rates, drive down solid amounts, and produce higher-quality products.