THE CONSERVE TEAM

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CONSERVE AT A GLANCE

CONSERVE: A Center of Excellence at the Nexus of Sustainable Water Reuse, Food, and Health was established in 2016 through a $10 million grant from the United States Department of Agriculture (USDA) National Institute for Food and Agriculture (NIFA) to the University of Maryland School of Public Health. A long-term goal of USDA-NIFA is to “solve critical water resource problems in rural and agricultural watersheds across the United States”. Within this framework, CONSERVE employs a systems approach to evaluate the availability (quantity and quality) of nontraditional irrigation water sources (e.g., recycled water, brackish water, return flows) that could be used to help agricultural producers conserve groundwater; identify the socio-behavioral, economic and regulatory factors that impact the use of these sources; and develop, implement, and evaluate on-farm water treatment technologies for the safe and successful use of nontraditional irrigation water. We then share this new knowledge with agricultural and non-agricultural communities, and employ experiential education to teach, train, and inspire future leaders.

There are multiple unique strengths to CONSERVE. Our exemplary and diverse team includes researchers, extension specialists and educators from two U.S. regions: the Mid-Atlantic and the Southwest as well as partners from Israel’s Arava Institute for Environmental Studies (an international leader in agricultural water reuse). We continually seek to partner with water reuse leaders from academia, government, industry and non-profit sectors. Our proven collaborative capacity speaks well for the success of CONSERVE and will allow us to maximally leverage existing resources. Our focus on the Mid-Atlantic and Southwest regions highlights two diverse climates that are in different stages of need for nontraditional irrigation water sources. Specifically, the Mid-Atlantic is currently not experiencing serious water shortages, and the integration of new irrigation water sources and emerging on-farm water treatment technologies at this time represents a proactive approach to agricultural water security. In contrast, the Southwest region is experiencing severe water shortage crises, and thereby represents a need for reactive solutions to water insecurity.

This report provides an overview of the progress of CONSERVE throughout our third year of funding.

OUR CONSERVE MISSION
To facilitate the adoption of transformative on-farm treatment solutions that enable the safe use of nontraditional irrigation water on food crops.

OUR CONSERVE VISION
A national resource bringing together research, outreach, and education to effectively reduce the nation’s agricultural water challenges that are exacerbated by climate change.
Characterizing the Availability and Quality of Nontraditional Irrigation Water Sources

Mapping Nontraditional Irrigation Water Sources

CONSERVE researchers have been characterizing the quantity of nontraditional irrigation water sources (e.g., wastewater treatment plant effluent, vegetable processing plant effluent etc.) available in Arizona (AZ), California (CA), Delaware (DE) and Maryland (MD) through the development of a user-friendly geospatial (GIS) platform. The GIS platform now contains information on over 2,300 discharging facilities, as well as crop data layers, hydrology layers, and soil type. The research team has also developed a decision support system to identify hotspots for use of recycled water for agricultural irrigation. The first version of the decision support system has been developed for California and the team is working on development of the system for other study regions.

Characterizing the Quality of Nontraditional Irrigation Water Sources

CONSERVE researchers have utilized cutting-edge analytical technologies, as well as gold standard culture-based methods, to comprehensively characterize the quality of nontraditional irrigation water sources across four states. Specifically, the team has conducted bi-weekly field sampling at 22 sites in the Mid-Atlantic and the Southwest over a two-year period. Tested sites include water reclamation sites, non-tidal freshwater rivers, brackish rivers, ponds, vegetable processing facilities and farms employing return flows.

In total, nearly 5,000 water samples have been collected, processed, and analyzed for basic water quality parameters (e.g. pH, turbidity, water temperature, nitrates, etc); bacterial indicators; bacterial, viral and protozoal pathogens; phenotypic antimicrobial resistance; pharmaceuticals and personal care products; and herbicides. In addition, all samples have been DNA extracted, purified and sent to the University of Maryland School of Medicine’s Institute for Genome Sciences for 16S rRNA gene sequencing, and a subset of samples has been sent to CosmosID for shotgun metagenomic sequencing. A subset of reclaimed water and pond water samples has also been incorporated into a novel methods-development study in a CONSERVE lab where DNA labeling methods have been coupled with sequencing methods to tease out the proportion of bacterial communities that are metabolically active (viable) within each water sample. To our knowledge, these are the first data of their kind. We have also partnered with the Food and Drug Administration’s GenomeTrakr Network (administered through the Maryland and Arizona State Labs), enabling whole genome sequencing of >500 Salmonella
isolates (recovered from our water samples) to be completed.

Our data have resulted in the most comprehensive microbial, chemical and physical characterization of nontraditional irrigation water sources that has ever been carried out in the U.S. We are currently working directly with the Division of Produce Safety in the Food and Drug Administration’s Center for Food Safety and Applied Nutrition, analyzing our data such that the findings can immediately inform the refinement of the Food Safety Modernization Act’s, Produce Safety Rule.

In addition to our extensive field sampling effort, the Mid-Atlantic CONSERVE sampling team has been collaborating with researchers at Hood College on a pilot project entitled RRIPER: Rooftop Runoff Irrigating Produce Eaten Raw. Throughout the study, water, soil, and leaf samples (n=186) were collected and tested for generic _E. coli_ and total coliforms. In addition, DNA was extracted from all samples and sent to the Institute for Genome Sciences for 16S rRNA gene sequencing and the resulting data are currently being analyzed. Irrigation with rooftop harvested rainwater is increasing in multiple areas of the U.S.; however, comprehensive water quality analyses of this water source are lacking. Our data will inform the development of appropriate water treatment technologies that may be needed to ensure the suitability of harvested rainwater for food crop irrigation.
Developing Innovative Treatment Technologies to Improve the Quality of Nontraditional Water Sources Used to Irrigate Food Crops

**Implement and evaluate on-farm, zero-valent iron biosand filtration systems in the Mid-Atlantic**

CONSERVE team members have developed an innovative zero-valent iron (ZVI) biosand filtration system that is low cost, low energy, and shows promising results with regard to removing both chemical and microbial constituents from recycled water sources. To date, successful laboratory, greenhouse and small-scale field experiments have been completed.

In an inline-irrigation system in both laboratory and field settings, filters removed 90-99% of *E. coli* and *L. monocytogenes* and treated bacteria were less persistent on irrigated leafy greens, yielding possible food safety benefits. Laboratory and field trials show that ZVI biosand filtration can be more effective than sand filtration in reducing *E. coli* in potential irrigation water sources. Laboratory batch studies have also demonstrated benefits of incorporating nano-silver-biochar within the ZVI filtration set-up.

**Implement and evaluate on-farm, UV and ozone systems in the Southwest**

The CONSERVE team is currently evaluating ozone and plant-based antimicrobials individually and in combination for the treatment of produce wash water and irrigation waters from various sources at the laboratory scale. A test protocol is currently being developed for the evaluation of these systems under field conditions using the experimental testing stand being constructed at the University of Arizona Maricopa Agricultural Farm.

The CONSERVE Laboratory Core has completed comprehensive analyses for selected pharmaceuticals and personal care products (PPCPs), and herbicides on all field samples collected from the inception of the Center to present. Together with the teams that are developing and evaluating on-farm water filtration systems, we are currently investigating whether improvements to our on-farm water treatment technologies result in further reductions with regard to PPCP levels in treated water.
Understanding the Factors that Influence the Adoption of Nontraditional Irrigation Water Sources

Social, Behavioral and Economic Factors

CONSERVE team members have completed 11 economics experiments examining consumer preferences for traditional vs. nontraditional irrigation water sources, surveying more than 4,000 adult participants in both the United States and Israel. The team has examined consumer preferences for using nontraditional irrigation water to produce a total of 17 products (strawberries, blueberries, spinach, broccoli, olive oil, olives, dried olives, grapes, grape juice, raisins, baby carrots, almonds, seaweed salad, seaweed snacks, seaweed noodles, red and white wine, dates, clementines, cotton t-shirts).

We also surveyed respondents regarding 21 potential branding names for reclaimed water. The results suggest that names that invoke desirable characteristics of the water — pure, eco-friendly, and advanced purified were viewed favorably. Overall, the extensive research conducted by the CONSERVE behavioral economics team has increased awareness and understanding of opportunities and barriers to nontraditional irrigation water use on food crops and other commodities.

Examine the legal, regulatory, and policy frameworks for nontraditional irrigation opportunities and implementation.

The CONSERVE legal team has completed research on state water laws currently implemented in California, Arizona, Virginia, Maryland and Delaware. In addition to the general research on water laws in the subject states, research has also been completed on the legal treatment of nontraditional or recycled water in the above-mentioned states. A draft of the report addressing on-site water reuse in California, Arizona, Maryland, Delaware and Virginia is completed. The report presents feasible approaches for implementing nontraditional irrigation under existing laws, regulations and policies; and achievable opportunities for shaping future laws, regulations and policies.

The CONSERVE legal team has also conceptualized and spearheaded three short-term study abroad programs that have been completed in Israel and the West Bank. On each trip, a group of interdisciplinary CONSERVE Scholars (from law, public health, agriculture, social work, business, computer science etc) were joined by Dr. Clive Lipchin, a CONSERVE Collaborator at the Arava Institute for Environmental Studies in Ketura, Israel. Together, the group traveled throughout Israel and the West Bank, where they studied the region’s diverse approaches to water reuse for agriculture.

4,000 adult subjects participated in economic experiments in the U.S. and Israel examining consumer preferences for foods grown with traditional vs. nontraditional irrigation water sources

3 short-term study abroad programs to Israel and the West Bank to examine approaches to water reuse for agriculture
Communicating the Message: Outreach and Extension

The CONSERVE Extension team has completed a growers needs assessment among over 900 growers, collecting survey data on knowledge and concerns related to the use of nontraditional irrigation water sources. This work will help address an important knowledge gap regarding farmers’ views and concerns related to nontraditional water used to irrigate agricultural crops eaten raw.

With the survey data, we completed a regional comparison and found that the Mid-Atlantic and Southwest regions differ in almost all topics covered by the survey. The two regions were significantly different in terms of all demographic characteristics surveyed (age, race, ethnicity, gender). Primary water source, concern about water availability, importance of nontraditional water, and willingness to supplement with nontraditional water sources all differed significantly between the two regions. Regional differences had the biggest impact on the willingness to supplement with nontraditional water compared to size of farm and primary water source. Interestingly, there was no difference in the way respondents in each region answered questions about access to nontraditional water sources and willingness to supplement with nontraditional water sources if the water quality was as good as or better than their current water source. Water quality and health were the largest areas of concern related to the use of nontraditional water sources in both regions. To share our findings with agricultural and non-agricultural communities, we have published an Extension article that summarizes our needs assessment. The article has been published in 16 agriculturally-related news outlets, social media sites, and e-newsletters.

Moreover, we have produced multimedia materials that address our medium term outcome of developing active-learning based educational modules. These materials include: 1) an interactive, virtual water sampling lab; and 2) a video explaining how humans and food are both integral components of the water cycle (these are available on conservewaterforfood.org). We have also completed video case studies in both the Mid-Atlantic and Southwest regions to
highlight agricultural producers that are already using recycled water to irrigate food and/or forage crops.

Most importantly, we have gained trust in agricultural communities, an important step for future implementation of on-farm technologies to treat and use nontraditional irrigation water. Towards the objective of integrating knowledge generated by CONSERVE to preeminent extension and outreach, the Extension team has developed high-quality and accessible materials (definition sheet, web content, food safety/microbiology learning modules, groundwater change maps, animations) and members of the Extension Team have presented at nearly 100 stakeholder-based conferences. The Extension Team also interfaces with two regional high-level Extension Advisory Committees, one in the Mid-Atlantic and one in the Southwest, comprising local growers, policy makers, and academics.
Inspiring the Next Generation of Leaders Engaged in Sustainable Water Reuse on Food Crops

CONSERVE Educational Materials

The CONSERVE team hosted workshops and exhibits at the National Science Teachers Association Meeting, established an Educator Advisory Board, designed two educational digital modules related to water sampling and microbial water testing, and produced two infographics on the history of water use/reclamation, two digital narratives on the collection/analysis of nontraditional water samples, and interactive outbreak investigation modules.

CONSERVE Scholars at work

CONSERVE has influenced the training of at least 105 scholars (40 undergraduate students, 43 graduate students, 6 post-doctoral fellows, and 16 technical personnel)

CONSERVE has held monthly webinars for the CONSERVE Scholars. Each month, a Scholar presents their data to the group for discussion. At least twice per year, the webinar includes professional development presentations, such as technical writing for the development of peer-reviewed manuscripts. We have also held two CONSERVE Scholar summer workshops in collaboration with SESYNC (an NSF-funded National Socio-environmental Synthesis Center here at the University of Maryland), which provided data analysis, science communication and data visualization training to a total of 42 CONSERVE scholars. The impacts of the workshop include improved ability of scholars to analyze, communicate about and visualize the findings associated with their CONSERVE research.

Moreover, we have successfully completed two terms of the CONSERVE Summer Internship Program (SIP) and a third cohort began in June 2019. Each summer, we have received between 18-30 completed applications, including many from applicants who identify as underrepresented minorities, for 5-8 positions. Webinars are conducted every other week over the course of the 8-week internship and the interns present their experiences to the cohort at the end of the experience. The mentors and summer interns completed exit surveys, and overall, close to 100% of interns and mentors were satisfied or very satisfied with their experiences.

undergraduate students have participated in the CONSERVE Summer Internship Program with CONSERVE teams around the country. A primary goal of the program is to support Science, Technology, Engineering and Math (STEM) training among students from underrepresented minority groups and/or disadvantaged backgrounds

CONSERVE Scholars — undergraduate and graduate students, post-doctoral fellows, and technical staff — have participated in CONSERVE research, education, extension, and professional development activities
CONSERVE Year 3: Communicating Our Message

Peer-Reviewed Publications to date:


(Peer-Reviewed Publications to date, continued)


43 peer-reviewed articles published that feature CONSERVE research

4 videos or other multimedia generated by CONSERVE team members
CONSERVE Team Working in the Field Around the Nation and Around the World

Above: CONSERVE Summer Interns collecting wastewater effluent samples.

Below: The CONSERVE Mid-Atlantic team at the annual Maryland Day guiding participants in an art project that teaches students about water resources.

Above: The CONSERVE Mid-Atlantic team sampling.

Below: CONSERVE scholars visiting Israeli water reuse sites.
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