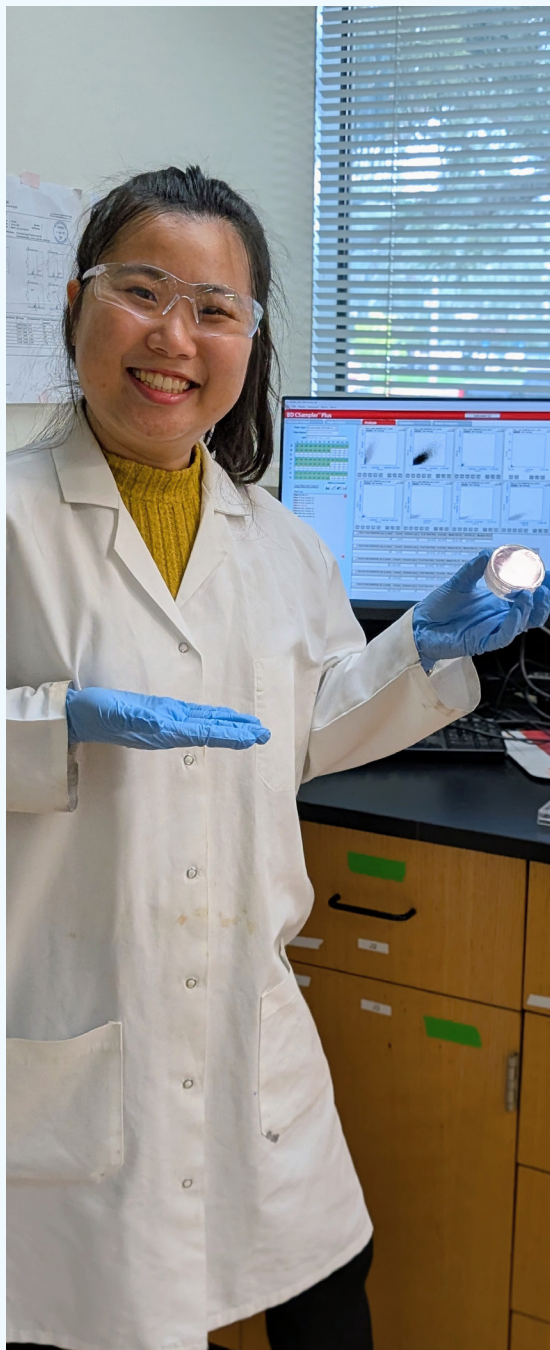




AWWA WATER SCIENCE

Theory and Practice of Safe, Sustainable Water www.awwawaterscience.com



Jade Luangphairin works with a flow cytometer.

Natchaya “Jade” Luangphairin

Having recently published an article in *AWWA Water Science*, Natchaya “Jade” Luangphairin answered questions from the publication’s editor-in-chief, Kenneth L. Mercer, about the research.

Spotlight Article

Evaluating State Nitrification Action Plans for Controlling Distribution System Nitrification and MDBPs

Natchaya Luangphairin, J. Alan Roberson, and Katherine Alfredo

Where are you studying, and what is your research focus?

I am a PhD candidate in the Department of Civil and Environmental Engineering at the University of South Florida (USF) in Tampa, Fla. My research focus has been on drinking water treatment and removal of emerging contaminants—specifically by exploring ways of applying community dynamics and agent-based modeling to biofilm development in a water treatment plant’s biological filter.

I’m also involved in analyses that aim to understand how evolving policies and treatment practices affect water quality. Because of that, I really enjoy statistics, working with data, and geeking out over cool visualizations that could later inspire my own. My research focus has not changed, but it has definitely broadened over time as my experience, interests, and understanding of the water sector have grown.

What path of education and training have you followed?

Long before I began formal scientific training, I was conducting imaginary experiments while playing “scientist” with my younger sister, June.

That childhood fun became formal when I received training at a national research center in Thailand (in food science); I cultured bacteria from yogurt and stool samples and even learned how to ferment fish sauce. That led me down the biotechnology path, where I earned my associate's degree and spent a few years in quality control, testing the stability of drugs for a pharmaceutical company.

At the time, I knew I wanted a career that would improve people's lives and naturally thought I would do that through health science. However, while completing my undergraduate degree in chemical engineering at USF, I stumbled upon the water sector through a research co-op at the City of Tampa's water utility. Since then, my career path has been clear: I wanted to work in water. With the encouragement and the confidence I gained from my City of Tampa coworkers, who taught me to run jar tests, I approached Dr. Katherine Alfredo and later began my PhD program doing water quality and policy research under her guidance.

How would you explain your research to someone without a background in water science?

Most water utilities disinfect drinking water with free chlorine or chloramine. Free chlorine is stronger, but when it reacts with natural organic matter, it can form harmful disinfection byproducts (DBPs). To reduce DBPs and meet the US Environmental Protection Agency's rule, many utilities use chloramine, which is less reactive, produces fewer DBPs, and provides a longer-lasting disinfectant residual throughout the distribution system. However, chloramine is made by adding ammonia to chlorine. If that bond breaks, free ammonia becomes food for bacteria, which converts ammonia into nitrite and nitrate (nitrification). Elevated nitrite is especially concerning for infants because



Jade (front, left) conducts field sampling at a water treatment plant.

it can interfere with the blood's ability to carry oxygen, causing "blue baby syndrome."

As nitrifying bacteria grow, they can form biofilms on pipes and increase disinfectant demand. This demand uses up the residual needed to protect water as it travels to consumers' taps, so more microbes can grow, creating a cycle that gets even worse during hot summers. To help prevent this, some states require utilities to have nitrification action plans (NAPs). My research identifies which states require them and which do not, the key considerations behind those policies, and the immediate and long-term effects of implementing NAPs. These findings can help policymakers make more informed decisions.

What motivated the research discussed in your AWWA Water Science article?

This research in our *AWWA Water Science* article, titled "Evaluating State Nitrification Action Plans for Controlling Distribution System Nitrification and MDBPs," was motivated by the growing number of water systems switching to chloramine and the need for nitrification control plans. Chloraminated systems can be vulnerable to distribution system



Jade (front, left) enjoys a meal with friends.

nitrification and loss of disinfection residual, so utilities need clear guidance to recognize early warning signs and take action before nitrification becomes a larger problem. Nitrification action plans are not federally mandated, and requirements vary by state. With several states requiring utilities to develop and implement them, we're trying to understand whether these state-level mandates help utilities minimize nitrification and maintain chloramine residuals, and whether they introduce any trade-offs related to DBPs.

Is there another study that influenced your own work?

Yes, but there are so many! This article was developed in collaboration with members of the Association of State Drinking Water Administrators (ASDWA) and builds on previous studies that identified nitrification challenges in drinking water systems. To mention a few that were most influential: (1) Maura Allaire and Michael Pennino's publications on patterns and trends in nitrate violations; (2) Chad Seidel and Carleigh Samson's work that focuses on modeling relationships between policy and water quality factors; (3) Lihua Li and Stephen O'Neill's article that introduced statistical approaches to assess the impact

of an intervention; and (4) an intensive statistics and machine-learning program at the University of Michigan–Ann Arbor, which Dr. Alfredo sponsored me to attend after recognizing my interest in exploring these methods more deeply. The program introduced me to multilevel modeling, among other tools, which I immediately applied to strengthen the study. Beyond academic literature, this work and the research that followed has continued to be shaped by conversations with my advisor, technical experts, staff at the City of Tampa, and my colleagues at USF.

Did you use any new techniques or methods?

Yes! The methods themselves were not necessarily new, but we applied techniques more commonly used in the social sciences, health sciences, and economics to examine drinking water quality and policy. We combined difference-in-differences and interrupted time-series analyses with autoregressive integrated moving average models to estimate how nitrification action plans affected the quality of water delivered to customers' taps. The outcomes included the likelihood of positive total coliform detection, disinfectant residual levels, disinfection byproducts, and indicators of nitrification. We also used multilevel modeling to account for differences across water systems and changes over time.

What surprises or setbacks did you encounter?

I remember feeling like banging my head against the wall when nearly every statistical test came back significant. My data science professor, Dr. Qing Lu, suggested that I read Mingfeng Lin's article, "Too Big to Fail: Large Samples and the p -Value Problem." That changed how I viewed p -values. It taught me not to rely on statistical significance alone and pushed me

to think more carefully about effect sizes, context, model structure, nonlinearity, and methods such as multilevel modeling. The data itself also presented challenges. Sometimes it was complex; other times, it was not readily available at all. For that I'm especially grateful to the ASDWA, the steering committee, and many water professionals who responded to my call for help by sharing utility data, completing surveys, and providing guidance.

Switching over to laboratory work—well, that's full of surprises, too, like having your flow cytometer break when you need it most. I have learned that experiments do not always go as planned and that unexpected results are not always a bad thing. Each challenge teaches you to troubleshoot, adapt, stay creative, and ask for help, even from strangers. On that note, does anyone know how to fix a flow cytometer fluidics issue?

What ideas for further exploration were prompted by your latest research?

My latest research and conversations with colleagues have made me think more seriously about how we can advance modeling in the water sector. As emerging contaminants and available data sets increase, so does the need for accurate, usable models. That is exciting, especially when data and AI tools are so widely available. However, many models still capture only part of a system and struggle with transferability and interpretability.

Building on ideas shared by others, I believe three areas deserve particular attention. First, researchers need a shared water-data warehouse that brings together high-quality data from different systems. Second, we need a safe and secure platform for transparent, collaborative coding so researchers can test, validate, and improve one another's work while clearly communicating each model's limitations. Third, researchers should continue testing hybrid models that combine physics-driven and data-driven methods. I believe this is one of the most promising ways to improve the accuracy of existing models without losing their scientific meaning. Together, these efforts could help utilities monitor their systems, make more reliable decisions, and feel more confident adopting modeling tools in practice.

How do you enjoy spending your free time?

I enjoy spending my free time with family and friends and exploring new places. With the World Cup soccer tournament having taken place close to home this year, I have been thinking about some of my favorite memories from traveling to South Africa with my family during the 2010 World Cup, singing “Waka Waka” and being woken up by a childhood friend at 4:00 a.m. to go fishing on a beach in Cape Town. I think I even saw a whale!

I also love good food and enjoy recreating my favorite dishes at home, sometimes with mixed results. When I want a creative escape, I turn to crafting, building models and kits, and playing guitar. These are the things that simply make me happy.

What is the most exciting aspect of your work in the world of water?

What excites me most about the world of water is the people at the heart of it. I love hearing how water has shaped their lives, their families, or even led them to careers in the field. Those stories make me feel my research is connected to the people it is meant to serve. I also get to work with people who care deeply about what they do and are equally committed to supporting others as we take on new challenges to keep the water safe.

There is a strong sense of shared purpose that extends beyond major infrastructure projects and groundbreaking research. You can also see it in the way people share knowledge and communicate, especially when the issues are complex, sensitive, or contested. I have seen my mentors stand before the public and lead those conversations with honesty and care—it is incredibly inspiring. I am especially grateful to the mentors whose guidance has shaped the professional I hope to become and to my family, who now see me as the “water expert” of the house. That combination of personal stories, shared purpose, and committed people is what makes working in water so exciting to me. 💧

To learn more about Jade's research, visit the article, available online at <https://doi.org/10.1002/aws2.70036>.

<https://doi.org/10.1002/awwa.70139>