November 2023

The Water bLog

newsletter

Utah Center for Water Resources Research at the Utah Water Research Laboratory

Photo courtesy of Brent Jacobson

Message from the Director

David G. Tarboton,
UWRL /UCWRR Director

What is that in the water? What is that in the air? At the UWRL much of our research is focused on environmental quality where we emphasize an integrated engineering and science approach to measure, understand, and find sustainable solutions to environmental problems.

This issue of the Water bLog newsletter highlights efforts to understand and inform management for two types of pollutants causing concern in Utah: one in the air, and the other in the water. Randy Martin's work focuses on the ammonium nitrate contributing to Cache Valley's poor air quality. David Stevens and Joanna Hou are collaborating on projects to predict cyanotoxins and algal blooms in Utah's lakes and reservoirs. By identifying the causes of both these kinds of pollutants and refining our ability to monitor them, our researchers can inform policies on warning systems and pollution reduction plans. ■

David Tarboton, UWRL/UCWRR Director

The projects highlighted in this issue of the Water bLog represent a fraction of the active research in which the faculty and students at the UWRL/UCWRR are engaged as they continue to generate the knowledge needed to solve water-related natural resources problems throughout Utah, the nation, and the world.

Visiting scholar Sarah Osama Makled from Egypt prepares water samples for algal bloom research.

Photo by Alyssa Regis

Welcome!

The Water bLog is the semi-annual newsletter of the Utah Center for Water Resources Research, housed at the Utah Water Research Laboratory (UWRL).

The Center supports the development of applied research related to water resources problems in Utah and promotes instructional programs that will further the training of water resource scientists and engineers.

Each issue of The Water bLog reports on a selection of current or recently completed research projects conducted at the UWRL. More information is available online at:

https://uwrl.usu.edu/research/ucwrr

INSIDE

UtahStateUniversity®

The Air You Breathe:

The role of ammonium nitrate in Cache Valley's air quality

Photo courtesey of Randy Martin

Cache Valley is known to have some of the worst air quality in the country. In fact, the valley has the nation's highest ammonia levels, with poultry farms being one of the largest sources of ammonia in Cache Valley that contribute to bad air quality. Winter inversions only make matters worse.

Inversions and Air Quality

In winter inversions, cold stagnant air gets trapped in the valley during periods of high pressure. Snow on the ground reflects back the sun's radiation, and because the ground doesn't absorb that radation and warm the air to allow for air mixing, particles like ammonia start to build up.

Ammonium nitrate (NH_4NO_3) and other fine particulates are a significant source of PM2.5 particulate matter, so called for their small particle size (2.5 microns or less in diameter). When ammonia from agriculture combines with nitric acid from car exhausts and other sources, it creates ammonium nitrate particles that then become a significant source of fine particulate matter in the air. Breathing in these particles traps them in our lungs and causes health concerns.

While measurements indicate that Cache Valley is making continued improvements in air quality through PM2.5 reduction programs, the early winter months of 2023 saw some of the highest concentrations of PM2.5 in a decade, exceeding the national standard for 9 days. The brief high-pressure periods between storms during the winter also resulted in multi-day inversions.

Tracking Poultry Pollution

When an intense bout of avian flu early this year caused the poultry farming facilities in Cache Valley to lose about 1.5 million chickens, or about 60% of all the chickens in the valley, professor Randy Martin wondered if the decrease in poultry animals affected the ammonia levels at all. His team set up 25 samplers throughout the valley and looked at the results from January and February of 2023, then compared with data from the 12-year history of ammonia levels collected as part of the National Atmospheric Deposition Program (NADP).

Complicating Factors

Martin's results, corroborated by other sampling facilities, showed that ammonia levels went down by a significant amount, even with the bad inversion conditions this past winter. The decrease in chickens clearly had a substantial impact on ammonia levels.

However, by the time the study was set up, the poultry facilities

An inversion settles in Cache Valley (top), the pollution a stark difference from a clear day (bottom).

had already started repopulating chickens and had increased to about 800,000 chickens, or a little more than half of their original numbers.

While the increasing numbers of chickens certainly affected ammonia levels, another variable may have offset some of those increased emissions. The facilities had made changes at their chicken barns, specifically improving waste management systems, at the same time they were repopulating.

"That may have contributed to the decrease in ammonia that we saw, as well as the slightly lower number of chickens," Martin said.

Moving Forward

The study was successful in tracking reduced ammonia levels from agriculture, but Martin affirmed that consistent and frequent tracking of ammonia levels are necessary in order to better understand the full effects of changes to PM2.5 pollution as they relate to both agriculture facilities and to meteorology.

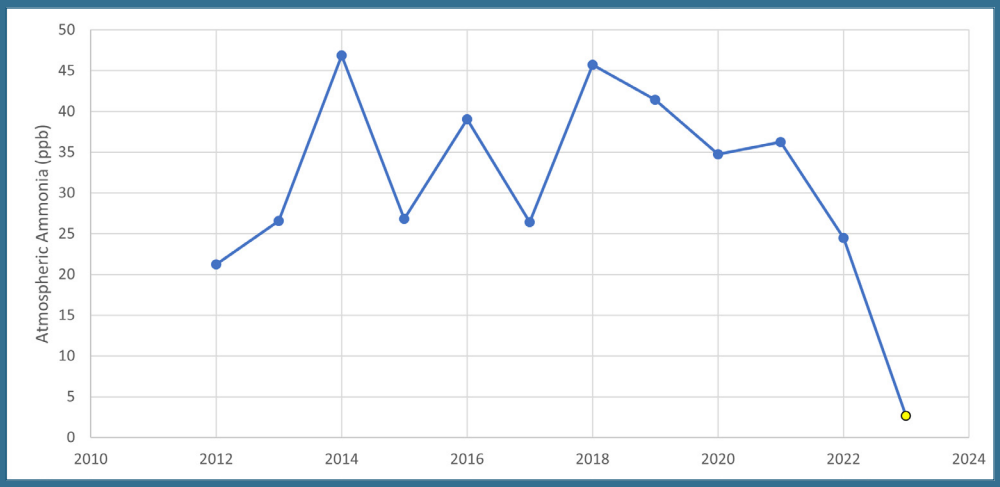
"We're moving in the right direction, but we're not all the way there and we always have to worry about the weather," Martin said.

Complete control over ammonia levels is not economically feasible since levels would need to decrease by at least 50% before we would see any sort of substantial change. But the other half of the ammonium nitrate problem is the nitric acid from vehicle exhaust. Martin also suggested several easy ways each of us can cut back on the nitric acid we put into the air:

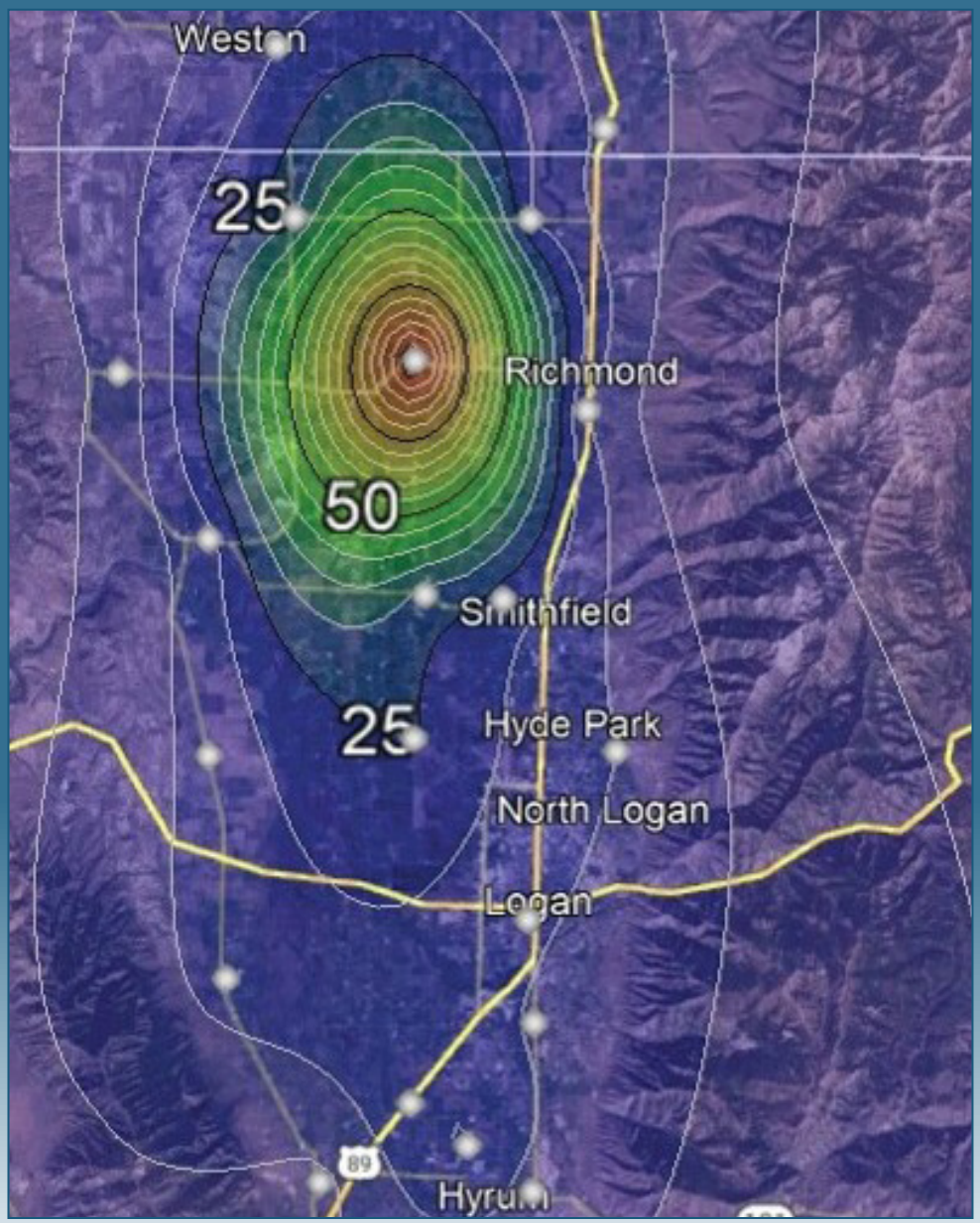
- Limit driving
- Use your most fuel efficient vehicle
- Don't idle
- Carpool to work and class

Each of these actions can help reduce the formation of PM2.5 and help to keep our lungs clear this year. ■

PI: Randal Martin
Professor, Utah Water Research Laboratory, Dept. of Civil & Environmental Engineering, Utah State University
(435) 797-1585, randy.martin@usu.edu



Average January concentration of ammonia from 2012 to 2023. The major drop in 2023 can be attributed to a significant decrease in poultry, as well as changes to barn management and other factors.



The contour map (above) shows ammonia spatial concentration around Cache Valley. The highest concentration is around rural Lewiston, located near a poultry facility.

Algae Alert:
unraveling the menace of cyanotoxins and harmful algal blooms

Photo by Alyssa Regis

News and neighbors have been whispering of water quality issues in places like Utah Lake and Zion National Park. Cyanotoxins. Algal blooms. Even instances of pet death circulate the news.

A warming climate and higher levels of phosphorus and nitrogen from human activities are creating increasingly favorable conditions for yearly "blooms" of these microorganisms in Utah's surface waters. Excess fertilizers in particular increase the nitrogen in our water sources through runoff from residential yards and farmlands.

Cyanotoxins and harmful algal blooms (HABs) are a result of cyanobacteria in the water. While 95% of cyanobacteria don't produce toxins—and we even use some as health food supplements, such as spirulina—some of these blooms produce toxins that pollute drinking water, cause pet illnesses, and contaminate fish.

Understanding the factors behind the growth of cyanotoxins and harmful algal blooms (HABs) is vital to predicting, preventing, and reducing the threat in recreational and drinking water sources.

Serious Cyanotoxins

Professor David Stevens and his graduate student, Brent Jacobson, are looking at nutrients that promote toxin production. They grew a culture of cyanobacteria (microcystins in particular) and used subsamples of varying nutrients and temperatures to measure toxin production after 3–4 days. They found that the ratio of nitrogen to phosphorus is important to the amount of toxin generated per cell of cyanobacteria. For the non-nitrogen fixing cyanobacteria in their samples, the lower the ratio, the more likely the toxins will be produced. In looking for predictors of toxin production, Steven found that a hub of bacteria is a red flag. When they see a bloom of algae, they can then examine the ratio of nitrogen to phosphorus to predict toxin production.

"The goal is to learn what causes these bacteria to produce toxins so we can predict ahead of time," Stevens said. Their work will help water utilities know when to find a different well or spring to use, help health departments alert the public to possible threats by shutting down beaches or issuing fishing warnings, and keep the toxins out of treatment plants.

Algal Bloom Genes

Professor Joanna Hou and her team are collaborating with Utah Division of Water Quality and Utah Division of Drinking Water to explore another facet of toxin prediction: DNA.

Genes can be powerful predictors of cyanotoxin and HAB concentrations. Hou is looking at DNA codes to see if particular samples of organisms found in water sources are capable of producing toxins. This, along with the nutrient ratio studied by Stevens, furthers the ability to predict a toxin bloom.

This past summer they monitored nine waterbodies in Utah using both traditional and simplified methods for DNA extraction. They are looking to develop a relationship between genetic results and other water quality parameter to reliably predict wehn toxin production and concentration will exceed health advisory limits.

Hou's preliminary results found that both the traditional and simplified gene methods were effective in detecting toxins. One particular microcystis gene had a positive correlation with HAB cell counts. Hou says the simplified method for DNA extraction may be a viable option for determining toxin level during an active HAB.

Both of these research projects provide guidance for water managers and public health officials in developing long-term monitoring programs to assess HAB threats. Accurate predictions are vital for early-warning systems to protect drinking water sources and limit recreational exposure.

Both Stevens and Hou are working with the state to monitor HABs and the potential toxins they produce. The better we understand cyanotoxins and harmful algae blooms, the better we can address the issue to ensure Utah's lakes and reservoirs can be enjoyed by all. ■

PI: David Stevens, Professor,
(435) 797-3229, david.stevens@usu.edu

PI: Liyuan Hou, Assistant Professor,
(435) 797-1533, liyuan.hou@usu.edu

Utah Water Research Laboratory,
Utah State University

The Utah Center for Water Resources Research (UCWRR), housed within the Utah Water Research Laboratory, is one of 54 state water institutes authorized by Congress in 1964. The UCWRR supports water research projects each year on topics relevant to the needs of the State of Utah with funding administered through the US Geological Survey (USGS) 104b program.

2022-23 USGS 104b Projects:

- Understanding Polluntant Mobilization at the Water-Shore Interface of a Drying Great Salt Lake *(S. Young)*
- Developing High-Resolution Seasonal snow Forecasts for Utah's Watersheds *(W. Zhang)*
- Quantifying the Effect of Potential Submerged Control Structures on Density-Driven Exchange Flows through the Breach of the Great Salt Lake *(B. Crookston)*
- Monitoring for Assessment of Cyanobacterial Hazards in Five Drinking Water Reservoirs in Utah *(D. Stevens—featured above)*

2023-24 USGS 104b Projects:

- Forage Crop Water Use Under Subsurface Drip Irrigation in Utah *(B. Barker)*
- Unveiling the Interactions Between Antimicrobial Resistome and Microplastics Influenced by Heavy Metals and Antimicrobics in Wastewater Treatment Plants in Utah *(L. Hou)*
- Enhancing Urban Irrigation Analysis in Utah with Remote Sensing *(Sowby, BYU)*
- Evaluating Cyanobacteria and Cyanotoxins in Surface Water Aerosols near Utah Lake *(S. Young)*

Read more about the UCWRR at:

https://uwrl.usu.edu/research/ucwrr/

Acknowledgment: "This material is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10623."

In the News:

AggieAir Flies the Logan River Flood

UWRL's AggieAir collaborated with Logan and Nibley cities to map the extent of the Logan River water surface during this year's high river flows.

AggieAir's unmanned aerial vehicles, or UAVs, offer a safe, quick and very high-resolution option for mapping the river's high flows and assessing both the extent of the flooding and the success of flood mitigation efforts.

The imagery they collected can be used to evaluate how accurately flood models predict future flooding events. Cities can use the data to improve models to better estimate potential future flows and plan for adequate prevention measures.

"You can help manage your risk by employing UAVs during floods," UWRL hydraulics professor Brian Crookston said. "The more that we can characterize the water and how it's moving, the better we can predict actual flooding potential on the river through modeling."

These models can then become the basis of decision-making for zoning, municipalities, bridges, roads and more.

READ MORE about the UAV Logan River flight:

Utah State Today | Cache Valley Daily | Route 50 | Herald Journal | KSL News

CIROH 1 Year Anniversary

The Cooperative Institute for Research to Operations in Hydrology (CIROH) is a "national consortium committed to advancing water prediction . . . and building community resilience to water-related challenges." The institute is celebrating one year since its creation.

In the first year, Jeff Horsburgh developed tools for sharing real-time hydrologic observations that will make it possible to build a larger network of operational data available to researchers, improving models and informing decision makers.

UWRL involvement is increasing with multiple CIROH collaborations beginning this year:

Belize Lane and Colin Phillips| Improving channel morphology representation in NextGen to refine flood inundation prediction

Pin Shuai | Advancing water management-hydrologic models to improve water forecasting in managed watersheds

Sierra Young | Advancing low-cost camera monitoring and image processing for operational hydrologic applications

Jeff Horsburgh | Developing lower cost snow monitoring technology to enhance streamflow and water supply forecasting

Jeff Horsburgh | Developing cyberinfrastructure for a national-scale Hydrological Information System (HIS) to enhance data availability

Dave Tarboton and Jeff Horsburgh | Advancing open data sharing in the CIROH community through HydroShare to ensure transparency and reproducibility

Dave Tarboton | Developing a HydroLearn workshop to collaboratively develop online learning modules on research to operations in hydrology-oriented topics

Future Issues:

"Bear Lake as a Living Laboratory"

Two UWRL faculty were awarded grants from USU's Institute of Land, Water, and Air to study aspects of Bear Lake in order to inform policy and management to preserve the lake for all to enjoy.

Contact:

Utah Water Research Laboratory
Utah State University
Logan, UT 84322-8200
(435) 797-3157

Director:
David Tarboton

Associate Directors:
Steven Barfuss
Jeffery Horsburgh

Writer:
Alyssa Regis

Publication Editor:
Carri Richards

uwrl.usu.edu

Utah Water Research Laboratory
UtahStateUniversity