Opflow
Cyanobacteria

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Hunter Adams, Ashley Cottrell, Sam Reeder, and Mark Southard are with the city of Wichita Falls, Texas (www.wichitafallstx.gov). Frances Buerkens is with Fluid Imaging Technologies (www.fluidimaging.com), Scarborough, Maine.

Use an Integrated Approach to Monitor Algal Blooms

One drinking water utility found a comprehensive, cost-effective strategy for monitoring toxin-producing cyanobacteria that can harm water quality.

BY HUNTER ADAMS, FRANCES BUERKENS, ASHLEY COTTRELL, SAM REEDER, AND MARK SOUTHARD

MOST DRINKING water utilities enter high-alert mode upon testing positive for microcystin. Staff at the city of Wichita Falls, Texas, Water Purification Laboratory responded calmly when they received that dreaded phone call in July 2018 because of their progressive approach to monitoring cyanobacteria.

Climate conditions are conducive to harmful algae blooms (HABs) and taste-and-odor events with increasing frequency and intensity. As a result, US Environmental Protection Agency (USEPA) regulations are moving toward requiring cyanobacteria monitoring. Proactive drinking water utilities are seeking a streamlined approach to monitoring cyanobacteria and nuisance algae.

INVESTIGATE BEFORE TAKING ACTION

No single method answers all the fundamental questions needed to make cyanobacteria treatment decisions and ensure a safe water supply. Those questions include the following:

1. Are cyanobacteria present in the reservoir?
2. What quantity of cyanobacteria are present?
3. Can the species produce toxins?
4. What's the concentration of cyanotoxins?
5. How do we know if we have a problem?

The city of Wichita Falls poses these key questions to identify nascent problems. When a cyanobacteria spike occurs, it's important to treat a reservoir while contamination levels are at barely detectable limits to diminish large-scale *Microcystis* outbreaks and cyanotoxin issues.

AN INTEGRATED MONITORING APPROACH

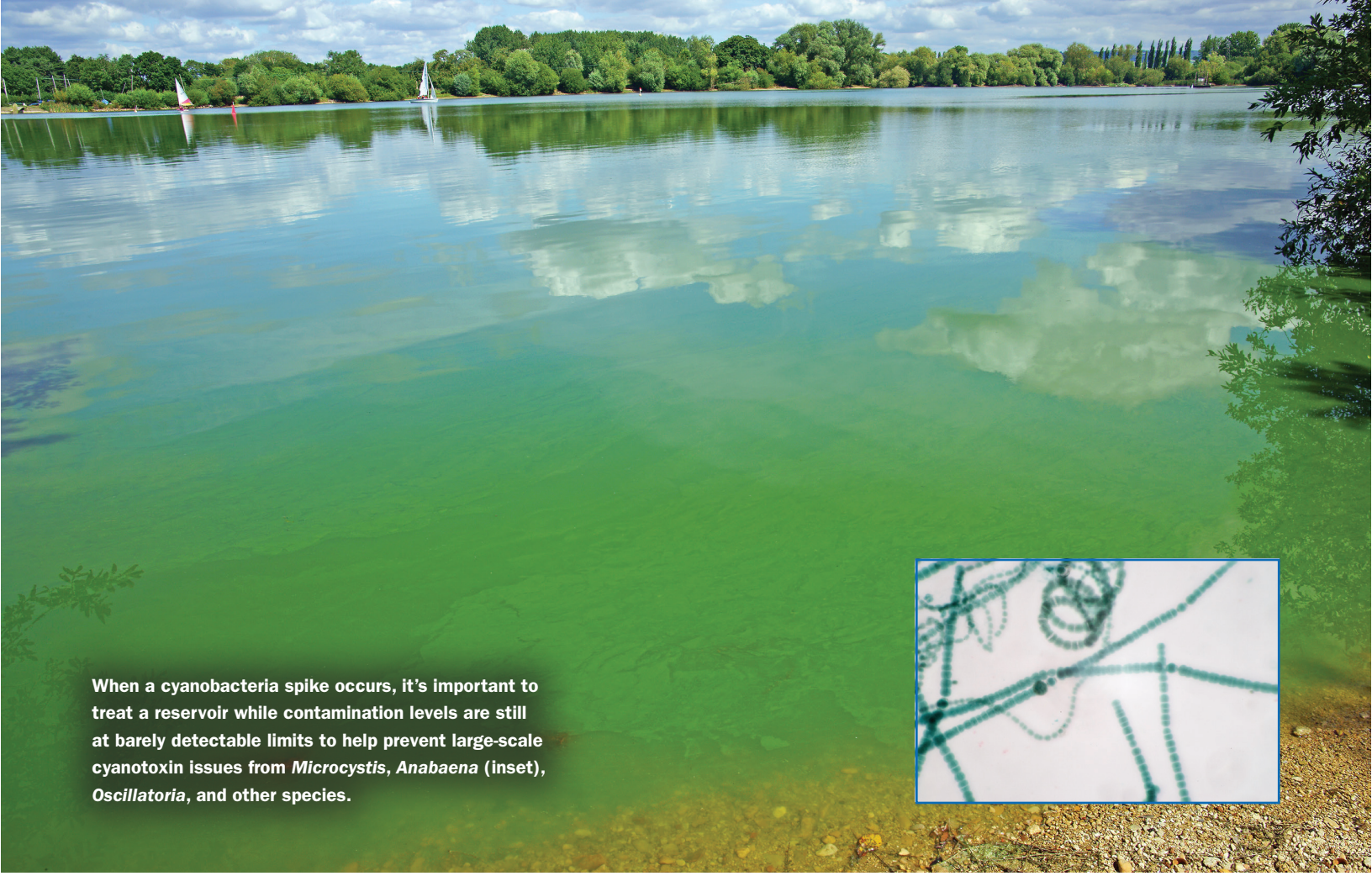
The city incorporated FlowCam, a flow imaging microscope from Fluid Imaging Technologies, with three other methods—quantitative polymerase chain reaction (qPCR) with the CyanoDTec from Phytoxigene, liquid chromatography–tandem mass spectrometry (LC/MS/MS) outsourced to a private laboratory, and gas chromatography–mass spectrometry (GC–MS) from Thermo Fisher Scientific—in an integrated strategy to monitor two lakes and one holding reservoir. The methods build on one another. Some are used multiple times each week for triage, whereas other methods, such as LC/MS/MS, are used only on an as-needed basis because of the high cost per sample.

Flow Imaging Microscopy. The city uses a flow imaging microscope to run samples three times each week in the summer and once each week in the winter. The instrument is used to identify and enumerate filter-clogging algae, taste-and-odor algae, and cyanobacteria. Besides an initial capital investment, there's no cost per sample and no limit to the number of samples that can be analyzed. The flow imaging microscope works quickly; it used to take the city three to four hours to do algae counts in the summer, but now it takes 15 minutes.

Elevated counts for filter-clogging diatoms or taste-and-odor producers are used to trigger immediate treatment. *Anabaena* concentrations of 100–200 chains/mL indicate an oncoming taste-and-odor event. *Microcystis* concentrations of 500 colonies/mL trigger immediate qPCR tests. Every region is different, so other utilities may find different counts have different effects. It's not a one-size-fits-all situation, especially with water quality variation and limited USEPA guidance.

qPCR. The city uses qPCR once each week to confirm if cyanobacteria in samples have toxin-producing genes. Having *Microcystis* in a sample doesn't mean the source water will have the neurotoxin microcystin. If the toxin-producing genes aren't present or activated, then microcystin will not be present. In fact, Wichita Falls sees *Microcystis*, *Anabaena*, and *Oscillatoria* in its reservoirs, and all three can produce microcystin. A flow imaging sample in July yielded 400 chains/mL of *Oscillatoria*, justifying an immediate qPCR test. The qPCR test that followed showed that microcystin-producing genes were present. The qPCR test costs $50 per sample and takes 40–60 minutes to yield results.

PCR is a positive/negative test, whereas qPCR is quantitative. The qPCR test establishes a calibration curve to quantify results. The qPCR results in July 2018 showed a detection with the PCR curve, but the cycle time was later than the lowest calibration standard.



When a cyanobacteria spike occurs, it's important to treat a reservoir while contamination levels are still at barely detectable limits to help prevent large-scale cyanotoxin issues from *Microcystis*, *Anabaena* (inset), *Oscillatoria*, and other species.

PHOTOGRAPHS: PJ PHOTOGRAPHY (MAIN IMAGE) AND RATTIYA THONGDUMHYU (INSET IMAGE), SHUTTERSTOCK.COM

This showed that microcystin-producing genes were present at >20 copies/µL but at a rate lower than their lowest calibration level. Despite the low levels, city staff played it safe and confirmed toxicity levels with an LC/MS/MS test.

LC/MS/MS. If the qPCR results are positive for the presence of toxin-producing genes, it's time to do a toxin test. For example, one city sample tested positive using an LC/MS/MS toxin test for microcystin. The toxin's concentration in lake and tap water samples was below the lowest calibration standard, tagging 0.015 ug/L.

LC/MS/MS analysis is currently conducted by a third party for Wichita Falls, with a standard turnaround time of two weeks (or five days at double the price). Microcystin and nodularin are analyzed by USEPA 544, and cylindrospermopsin and anatoxin are analyzed by USEPA 545. The battery of toxin tests for three samples (raw surface water and two plant samples) costs around $900.

Only two events to date have warranted a toxin test, a record that has made it cost-effective to outsource sample analysis. Flow imaging microscopy data and qPCR test results are used to justify either doing or skipping a toxin test. More than one type of toxin test is available, and the enzyme-linked immunosorbent assay (ELISA), a well-known method, is a lot cheaper than LC/MS/MS. However, ELISA results aren't always reliable. When it comes to public safety, reliability is critical. Thus, the city's team uses mass spectrometry, as LC/MS/MS results are reliable.

GC–MS. GC–MS analyses are also part of the toolkit the city of Wichita Falls uses to monitor taste-and-odor taxa. These analyses run three days each week to monitor 2-methylisoborneol (MIB) and geosmin, which are common taste-and-odor compounds in drinking water. A flow imaging count exceeding 200 chains/mL for *Anabaena* may indicate a taste-and-odor event is on the horizon because geosmin has been seen to increase with high *Anabaena* counts.

Wichita Falls treats its water with powdered activated carbon (PAC) to remove geosmin and MIB. Treatment with PAC is initiated when GC–MS results confirm the taste-and-odor compounds are present. Outsourcing sample analysis costs around $200 per sample for MIB/geosmin. The fastest turnaround time for sample results is one hour per sample. In a normal run, results for the entire sample set are available by the beginning of the next workday.

GETTING THE JOB DONE

In Texas, Wichita Falls faces formidable ecological conditions that are conducive to significant cyanobacteria blooms and taste-and-odor events. The city's water quality team has leveraged the best technologies to keep its water clean and its consumers happy. No single lab test provides all the answers.

Wichita Falls' multifaceted approach has reduced outbreak size and has all but eliminated taste-and-odor customer complaints. It's been more than two years since the city's last taste-and-odor outbreak, and increasing that number is one of the city's primary water quality goals.