Toxic algae cocktail brews in Lake Erie

Stew of farm runoff, invasive mussels, big rains poisons Toledo's water, sends lake back to its dark ages

By Dan Egan of the Journal Sentinel staff

Sept. 13, 2014 3:30 p.m.

The American public might have been shocked to see 50-foot-high flames dancing on a downtown Cleveland river in the late 1960s, but Frank Samsel wasn't.

His job was to keep the Cuyahoga River channel clear for the boats and barges that fed the industries lining its banks, and he knew the truth about the river. It was no longer the vital freshwater artery nourishing Lake Erie that nature designed it to be.

A Watershed Moment

It had become Cleveland's colon, and the lake was a toilet.

"I don't care if it was bacon grease or some cleaning agent at a galvanizing plant," Samsel recalled in an interview with the Milwaukee Journal Sentinel. "It all ended up in there."

He owned and operated a 57-foot boat equipped with a customized crane to haul aboard everything from floating cow carcasses to acetylene tanks. His crew used a special boom to skim oil slicks off the river.

Sloppy sewage practices and a political tolerance for the defiling of public waters by heavy industry had caused lakes and rivers across the continent to become dangerously polluted by the middle of the last century, but the public remained oblivious to how bad things had gotten until that rock-bottom moment on June 22, 1969.

The spark that dropped from a railroad bridge and set the river on fire proved to be precisely the disaster needed to save the nation's ravaged waters.

The flames shamed Congress into passing the Clean Water Act in 1972, which dramatically throttled back the human and industrial excrement that flowed so freely from pipes across the country.

Nowhere was the law's success more apparent than on Lake Erie. In little more than a decade, the warmest and shallowest Great Lake was transformed from a national embarrassment to a fish-filled icon for the power and the virtue of pollution control laws.

No more.

Lake Erie is sick again. Things might have been horrific 45 years ago when Newsweek proclaimed the lake dead, a time when schools of fish didn't so much swim as they floated. But they were never so bad that there was fear Lake Erie's water was in danger of becoming too poisonous to be purified at treatment plants for the millions of people who drink it.

Like Samsel a half-century ago, the scientists closest to the problem today have known for the past several years how bad things have gotten.

Modern farming practices, wetter springs and toxic-algae-spitting invasive mussels have conspired to produce late-summer poisonous blooms that can sprawl across nearly 2,000 square miles, threatening anew everything from beach-goers to public drinking water supplies.

The lake's famed fishery is also at stake — when the toxic green blobs die and decompose, they foster oxygen-depleted "dead zones" approaching the size of those that led to Erie's obituaries in the 1970s.

And the scariest thing about it all: State and federal regulators have yet to take the first step toward controlling the problem by invoking the Clean Water Act and declaring the ailing lake "impaired."

Such a listing would require a formal plan to reduce Lake Erie's annual diet of phosphorus, which is the catalyst for an ecological calamity now as fixed to the rhythm of the seasons as dandelion blossoms and fall foliage.

Samsel remembers being terrified of what might happen if a spark dropped as he skimmed volatile chemicals off the Cuyahoga. Scientists today are in the same boat, but now they're waiting for that spark — one that will force political action.

"What we need," Don Scavia, director of the University of Michigan's Graham Sustainability Institute, said with a rueful chuckle earlier this summer, "is a harmful algae bloom — that burns."

A toxic cocktail

It's Monday, July 28, and University of Toledo biologist Tom Bridgeman is showing a visitor a picture of a pint glass filled with a concoction so green and pulpy it could pass as a New Age health drink.

The reality: It's loaded with the toxin microcystin, which is produced by a cyanobacteria called microcystis, commonly referred to as blue-green algae.

The single-cell organisms live in colonies that can form 4-inch-thick mats and span hundreds of miles. The toxic algae is native to the Great Lakes, but for thousands of years existed at densities so low it did not pose a hazard to the ecological health of the world's largest freshwater system.

Many types of algae — not just toxic forms — were a problem in the middle of the last century in shallow western Lake Erie, as well as bays and harbors across the Great Lakes.

Fueled by phosphorus, a byproduct of sewage treatment, industrial processes and at the time akey ingredient in laundry detergent, those huge algae blooms largely disappeared following passage of the Clean Water Act and a separate Great Lakes phosphorus reduction agreement between the United States and Canada.

Lake Erie's phosphorus load averaged about 24,000 tons per year in the late 1960s and early 1970s. The new regulations called for a cap of 11,000 tons per year. Billions of dollars were invested in phosphorus-reduction technologies to meet the goal, and by the 1980s the blooms waned.

Today, Lake Erie's annual average phosphorus load remains around 9,000 tons, well under its 11,000-ton target.

Yet in the past 10 years, toxic blooms have exploded at a scale never before seen, leaving scientists scrambling to figure out why the lake is now retching a viscous green slime as nasty as anything an industrial pipe can belch. The water sample in Bridgeman's picture might have been scooped straight from the lake a few miles offshore from his laboratory east of Toledo, but it shouldn't be called water any more than a bottle of nail polish remover could be called water.

"You'd get really sick," Bridgeman says, when asked what would happen to someone foolish enough to gulp from the glass. "I mean, drinking that whole glass might be enough to kill you."

In low doses, microcystin causes rashes, vomiting and diarrhea. In higher doses it can induce liver failure. There have been no deaths attributed to it in the United States, but an outbreak in a public water supply in 1996 killed some 50 people at a dialysis center in Brazil.

Bridgeman took the picture 11 years ago because he'd never seen the green muck smother such a vast expanse of Lake Erie.

"That was considered back then a big event," he says. "Now it's just average."

So what is happening?

A big reason is that agriculture, the primary source of phosphorus, was left largely untouched by the Clean Water Act.

The law was designed to go after polluters that own pipes, referred to in regulatory jargon as "point sources." But the law never tackled farm runoff, which is classified as "non-point" pollution. The reason, basically, is treating what comes out of the end of a pipe is easy; tracking and regulating what comes off farm fields is profoundly more difficult, given the vagaries of weather, soil types, field pitch and the ability to monitor what is in the water on pastures.

At the time the Clean Water Act was conceived, it was thought that regulating point-source polluters would be enough to heal the nation's waters. And that did do wonders, even in the Lake Erie basin, one of the most heavily farmed watersheds in the country.

Farmers in the region today aren't sending Lake Erie any more phosphorus than they were in the days when the giant algae blooms waned. But other things have changed — up in the sky, down in the soil and throughout the waters of Lake Erie — that have added up to huge trouble.

It starts with the way crops are planted. Farmers have increasingly turned to no-till growing practices to prevent soil erosion.

This is good for keeping farm fields from washing away and muddying Lake Erie and its tributaries. But instead of fertilizer being churned into the earth and its phosphorus binding to the soil in a particulate form, the pellets now sit like a crust on top of uncultivated fields. This is problematic if rains hit before the fertilizer has a chance to be absorbed into the crops, because then the phosphorus washes away in a highly potent dissolved state.

When it comes to the ability to stoke an algae outbreak, the difference between particulate phosphorus and its dissolved form is like the difference between tossing a log on a campfire and splashing a can of gas on it.

Scientists estimate less than 30% of particulate phosphorus feeds algae, compared to more than 90% for the dissolved form.

This problem is growing right along with the size of farms in the region.

Larger agricultural operations — and the equipment it takes to run them — mean fertilizer is now more likely to be applied in late fall or early winter, when farmers have the free time and the ground is hard enough for their heavy machinery to roll. This further primes the fields for fertilizer runoffs if big spring rains roll in before the growing season — and historical data shows such rains have become more the norm on the western end of Lake Erie.

So while the overall tonnage of phosphorus making its way into Lake Erie has been steady for decades, the amount of dissolved phosphorus has more than doubled in western Lake Erie tributaries since the mid 1990s.

The net result: The amount of the nutrient flowing down key rivers in western Lake Erie able to fuel algae growth is now even higher than what it was when the lake was in trouble back in the 1970s.

And when that phosphorus hits Lake Erie, there is trouble in the water that wasn't pondered when algae-reduction plans were drafted decades ago.

Invasive quagga and zebra mussel numbers have exploded since the early 1990s, fundamentally altering the way life works in Lake Erie. The thumbnail-sized mollusks that arrived in the 1980s as stowaways in overseas ships are what biologists refer to as "ecosystem engineers."

This means they don't just live in the waters they invade, they rewire the way energy flows through them. In this case, mussels are a prime factor in the toxic algae equation because the brainless filter feeders are just smart enough to not eat toxic algae.

Lab experiments show the mussels gobbling up almost everything floating in an aquarium tank except microcystis. They spit it back with the vigor of an unsuspecting toddler being fed brussels sprouts.

This incessant filtering, over time, has decimated other algae populations, so algae outbreaks on Lake Erie have basically become a microcystis show.

"Lake Erie today is not the same lake it was in the '60s or '70s," says University of Michigan ecologist Gary Fahnenstiel. "It does not respond to nutrients the same way."

The toxic blooms have become so regular that they can now be forecast months in advance, based largely on how much rain fell in spring, and if that rain fell before the phosphorus being absorbed into crops. In early July, the National Oceanic and Atmospheric Administration predicted this year's bloom would be "significant" come late August and September.

Just down the shore from Bridgeman's lab, signs on a deserted Toledo public beach in late July were already warning would-be visitors to stay out of the water if it "looks like spilled paint."

Bridgeman is distressed by the predictability of it all. But he notes one encouraging fact: Lake Erie essentially flushes itself every 2.6 years — that is the time it takes for all the water in the lake to flow east over Niagara Falls and out toward the ocean. It is replaced by precipitation falling over the Lake Erie basin, as well as inflows from Lakes Michigan, Huron and Superior.

"If we come up with a solution to the phosphorus loading," he says, "the lake should recover within a few years."

But he frets that won't happen unless something drastic occurs to wake people up. He doesn't know what that might be; America's rivers, after all, don't burn anymore.

"It may take," he says, "a major city having to shut down its water supply for a while."

Invisible poison

It's Tuesday, July 29, and Richard Thorbahn, a retired school administrator and trustee for the Carroll Township Water and Sewer District east of Toledo, is wearing his farmer hat today.

He's working with a partner several miles south of Lake Erie, using a 1950s-era tractor guided by lasers to install drain tiles in a farm field.

This perforated tubing, placed about two feet under the field surface, is designed to channel excess water into streams that flow into rivers that feed the lake.

Thorbahn says the pipe he's laying actually alleviates the phosphorus problem because it allows water that hits the crops to first be filtered through the soil. He says water coming straight off the surface of the fields, instead of flowing down to the tiles, is more likely to be contaminated with excess fertilizer

"It's surface runoff," he says, referring to how agriculture contributes to the phosphorus problem in the lake. "It's not the tile system."

Scientists don't buy that. They say research makes it clear these plastic pipes help mainline the phosphorus into the lake, particularly when rains hit dry fields riddled with fissures and worm holes that channel the water straight into drain tiles.

Thorbahn knows as well as anybody the consequences of too much phosphorus making its way into the lake. In fall 2013, the rural water department he helps oversee, which serves about 2,000 people, was the first on the Great Lakes to be shut down due to microcystin.

The toxic cloud of water did not come out of a dangerously soupy batch of green water pumped into the treatment plant from Lake Erie.

It came out of the blue.

Water department superintendent Henry Biggert says he wasn't particularly worried in the days before the troubles began because there was no evidence of an algae bloom approaching his water intake, about 1,000 feet off the shoreline.

Water treatment plant purification systems can remove the toxin before it flows to customer taps, but those protective systems have to be dialed up to do so. Green cloudy water flowing into Biggert's plant is usually a bright red flag that microcystin trouble might be lurking in the lake water.

"Usually, when you're pulling algae through the treatment plant, you know," Biggert says. "You can smell it and you're constantly cleaning equipment."

But there was no such warning when routine lab testing started showing the amount of microcystin in his plant's finished product was about 3 parts per billion, well above the 1 part per billion threshold for drinking water set by the World Health Organization.

That level is a recommendation only; the microcystin threat is still so new in the United States that officials have yet to set drinking water standards for it.

Biggert says there was no evidence the contaminated water had left his treatment plant, but he took the system offline for two days so the 126 miles of pipe crisscrossing the district's 26 square miles could be purged.

"I couldn't live with the idea that it may be in our distribution system," he says.

Biggert was able to turn a couple of valves and switch his customers over to the water supply from the neighboring Ottawa County Regional Water System while his district weathered the microcystin surge. Even with that backup, the township recently purchased a $225,000 treatment system to better zap the toxic algae.

Two things about the Carroll Township shutdown were particularly frightening. The first was that the dangerous water looked like ... water.

The toxin, which breaks loose as the decaying algae cell walls collapse, was clear and odorless, and it was apparently drifting out in Lake Erie independent of the algae bloom that created it. The second frightening fact was how quickly Biggert's customers were faced with the prospect of brushing their teeth, washing their food and even having to bathe with bottled water.

Biggert cringes when he thinks what would happen if something similar occurred in a big city, one that can't just flip a switch and convert over to an emergency source.

"The lake could get worse," he says. "And if that's the case we — and a lot of other public water systems — will have problems."

The culprit in the crops

It's Wednesday, July 30, and farmer Norris Klump is sitting in a house on the southern Michigan farm his ancestors settled in the 19th century, trying to figure out how he and his fellow farmers have suddenly become culprits in the toxic water equation.

Many of them are working lands their grandfathers and great-grandfathers settled, and they see themselves as becoming better stewards of their inheritance with each passing year.

"We live and play and work here," says Klump, who farms just north of the Ohio-Michigan border. "Do I really want to do something that will hurt my kids? My grandkids? Of course not. If I could do something and this will stop, yes, I would. But I don't think we're the whole problem."

The corn, soybeans and wheat grown on the western end of Lake Erie wend their way through a series of industrial and natural processes that are the modern food chain to become everything from milk to hamburger to bread to soda sweetener. Some also ends up in your gas tank; Klump, like many farmers in the area, sells a portion of his harvest to one of the regional ethanol plants.

"I don't think people understand the hard sweat it took to clear this land and drain it — to grow food," he says. "Now people are like: Why are you growing stuff on this land?"

About 25 miles to the south, Steve Loeffler stands under a glaring sun outside his family farm a half-hour drive west of Lake Erie. He is both troubled and mystified at the algae blooms ravaging the lake he grew to love as a little boy fishing for perch with his grandpa.

It was the early 1960s, the lake was ailing, but his grandfather knew its prime fishing spots well enough to catch enough perch to eat it for lunch year round. He got through the winter with what he cached in his freezer. He called it brain food.

Loeffler is planning his own vacation on the lake in the next couple of weeks, and he worries that it's slipping backward to its dreadful state of the 1970s.

"When it breaks out," he says of the toxic algae, "it's a really serious problem."

But he doesn't see it as entirely a farmer problem.

"Everybody is going to have to do their part," he says. "The cities, the farms."

He points to leaky home septic systems (but scientists estimate such systems in Ohio are responsible for onlyabout 88 of the more than 9,000 tons of phosphorus the lake receives annually). He points to sewage overflows from urban areas like nearby Toledo (but combined sewer overflows in all of Ohio are responsible for about 90 of the more than 9,000 tons flowing into the lake annually).

For his part, Loeffler says he's cut his fertilizer applications in recent years by about half. So have a lot of nearby farmers, he says.

Loeffler also plants crops of radishes that never get harvested as part of a government-funded program to soak up excess nutrients. These cover crops also help anchor the soil when there is nothing else growing.

But only a sliver of his nearly 1,000-acre farm is planted with this cover crop. The government money to do more just isn't there, he says, adding that he'd plant more on his own — if he could afford to.

"Guys," he says with chuckle, "can do a lot more when they're making money."

Piloting a Dodge minivan down the ribbons of asphalt lacing Ottawa County farm country, Mike Libben, a county soil conservation program administrator, talks about the lengths farmers in northwest Ohio have gone to solve the algae problem.

He describes government programs that compensate farmers for forsaking crop acreage for grass buffers to catch soil and fertilizer before it rushes into streams.

He explains there is a fund to pay farmers to install dam-like structures for their drain tiles to hold back water if fields aren't saturated.

He points out that farmers are increasingly hiring soil consultants who break fields into garden-sized grids, and then sample those micro sections regularly for phosphorus and other fertilizer needs. "Prescriptions" are then written for chemical dosages for each grid section, often using GPS-guided equipment that allows farmers to tend to fields sprawling across hundreds of acres with the precision of a backyard tomato-grower.

They're motivated to reduce their phosphorus applications by more than a desire to do their part for Lake Erie.

"I've never thought that farmers are over-applying — because it's just so expensive," says Libben, himself a part-time farmer.

Federal data shows the price for phosphate fertilizer ran less than $200 a ton two decades ago, when the algae blooms were under control. Today the same fertilizer costs around $700 per ton.

At a co-op outside Oak Harbor, Libben says the fact that the store manager now must lock up his pile of the fertilizer shows just how precious the stuff has become.

"We could do everything right and there could still be blooms," Libben says.

Research shows farmers around Lake Erie lose only about 5% of the phosphorus they apply to runoff, but that's still enough to make runoff by far the largest source for the phosphorus fueling the algae outbreaks. State data shows that non-point sources in Ohio contribute an average of 3,987 tons annually to the lake's western basin, compared with 388 tons from point sources such as sewage treatment plants and factories.

Farmers and politicians often like to look north toward Detroit as a major source of the problem.

The city's discharges are a factor, but only 29% of Lake Erie's phosphorus load comes down the Detroit River, and that includes the collective outflows of Lakes Michigan, Huron and Superior. Due to the volume of flow coming down the river and the easterly path it takes toward Niagara Falls, scientists say this relatively diluted phosphorus load pales in comparison to agriculture's contribution to the blooms on the western end of Lake Erie.

Another source of phosphorus is nutrient-rich sediments dredged from shipping channels and disposed of in the open water, though the precise effect this has on algae blooms is unknown.

What is known is that agriculture is driving much of the problem, even if farmers are having a hard time digesting their role.

A 2013 Ohio State University survey of farmers in the watershed of the Maumee River, the largest tributary to Lake Erie, showed the vast majority of them acknowledged that farming practices were degrading water quality in the lake. Just not their practices.

"The majority of farmers agreed that nutrient management practices improve water quality (86.4%) and that their own practices are sufficient to protect local water quality (76.7%)," states the report.

In other words, more than three-fourths of the farmers believe they are doing their part.

But the lake is telling a different story.

'Things can always get worse'

It's Thursday, July 31, and Don Scavia is sitting in his third-floor office above a Starbucks in Ann Arbor at the edge of the University of Michigan.

Scavia is director of the university's Graham Sustainability Institute, and he says what's happening 50 miles to the south along the shore of Lake Erie is the definition of unsustainable.

"What we've been doing for the last century," he says, "is no longer working."

Scavia was co-author of a 2013 scientific paper that was, essentially, an autopsy of the 2011 toxic algae bloom — the largest in Lake Erie's history. The researchers blamed the evolution in farming practices and a bevy of spring storms. They also predicted that massive bloom was just a harbinger, due to the way phosphorus is now applied and a change in climate that is bringing more big spring rains.

"The perfect storm of weather events and agricultural practices in 2011 is unfortunately consistent with ongoing trends, which means that more huge algal blooms can be expected in the future unless a scientifically guided management plan is implemented for the region," explained study lead author Anna Michalak.

Such a plan appears a long way off; neither Ohio nor Michigan has declared Lake Erie's western basin "impaired" under the Clean Water Act, the first step toward creating a new phosphorus diet for the lake.

Pressure to do so is mounting.

A report by the International Joint Commissionreleased this year all but begged the states of Michigan and Ohio to declare the lake impaired. It called for a 41% reduction in dissolved phosphorus loads flowing each spring into the lake from the Maumee River.

Nobody knows how this is going to happen at this point, because the Joint Commission, a U.S.-Canadian body that oversees boundary waters issues, can't force farmers to do anything. So any measures taken by farmers to reach this goal would be voluntary.

And farmers want to keep it that way.

Last winter, the Ohio farm lobby pushed back against a proposal that would have given Ohio environmental regulators more authority to regulate wintertime applications of phosphorus-rich manure. The bill that passed instead requires farmers to receive training and get state certification to apply commercial fertilizer — and it gives farmers until 2017 to get those certificates.

Environmentalists hoped for greater protections, but the bill that did pass was celebrated by the agriculture industry. One trade publication headline read, "Ohio water quality bill gets revamped to buy time for research."

Andy McClure, administrator of Toledo's Collins Park Water Treatment Plant doesn't feel like he has a lot of time. It is late July and he is bracing for a peak algae season that is just weeks away.

He tries to pull up an image on his computer to show a visitor the National Oceanic and Atmospheric Administration website that uses satellite imagery to track Lake Erie's Harmful Algae Blooms — "HABs" in water-quality circles.

But every time he types HAB, the computer jumps to contact info for Henry Biggert — the Carroll Township water department director who had to shut down his system last year due to a microcystin surprise. He and Biggert, he explains, have been communicating a lot.

McClure notes Toledo already uses carbon and chemicals to keep the water tasting and smelling OK, and that equipment can also deal with any microcystin that might show up. But the treatment systems have to be cranked up to remove the toxin, costing his ratepayers about $3,000 per day during peak blooms.

He worries that someday levels of microcystin in Lake Erie could surge to the point his equipment cannot handle them.

"Things can always get worse," he says. "And that's pretty much how you have to think."

The 'perfect storm' — again

It's Friday, Aug. 1.

The NOAA website releases an image from satellite sensors showing bright red pixels on the western edge of Lake Erie. Those red flecks signal the first wave in the seasonal algae bloom water experts didn't expect until the end of the month.

Within hours, winds drive that relatively tiny toxic plume straight into the maw of the Toledo water intake.

An "urgent" email goes out at 1:20 a.m. Saturday to Toledo media, saying: "DO NOT DRINK TOLEDO PUBLIC WATER UNTIL FURTHER NOTICE."

And that's how fast a metro area of a half-million people can lose its water supply.

The media reports that a confluence of wind, temperature and algae bloom timing created the "perfect storm" for the unnatural disaster.

Those were the precise words Biggert used when his own water system went down less than a year earlier.

Two perfect storms in 11 months.

The alerts tell Toledo residents not to drink or even wash with what's coming out of their taps. They are told boiling will do no good, as it will only concentrate the toxin.

Toledo Mayor D. Michael Collins appears on television the following day. He tells people not to panic, but that their water is neither safe for humans nor animals. He says the National Guard is rolling in from all corners of the state with pallets of bottled water and portable water treatment plants.

And pre-mixed baby formula is on its way from Columbus.