

Mercury and algal blooms poisoned Maya reservoirs at Tikal

Enlarge / UC graduate student Brian Lane climbs out of the Perdido Reservoir.

Photo/Nicholas Dunning

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For centuries, Tikal was a bustling Maya city in what is now northern Guatemala. But by the late 800s CE, its plazas and temples stood silent, surrounded by mostly abandoned farms. A recent study suggests a possible explanation for its decline: mercury and toxic algal blooms poisoned the water sources that should have carried the city through dry seasons.

Tikal's Maya rulers built the city's reservoirs to store water from rain and runoff during the winter months. The pavement of the large plazas in the heart of the city tilted slightly, helping funnel rainwater into the reservoirs. Over the centuries, dust and litter settled into the bottom of the reservoirs, too, providing a record of what the environment around Tikal was like—and what was washing into the city's water supply. University of Cincinnati biologist David Lentz and his colleagues sampled layers of sediment dating back to the mid-800s, and they found that two of Tikal's central reservoirs would have been too polluted to drink from.

An X-ray fluorescence spectrometer (which identifies the

chemicals in a sample based on how they react to being zapped with an X-ray light) revealed that the sediment on the bottom of the reservoirs was laced with dangerous amounts of mercury. Lentz and his colleagues also found ancient DNA from blue-green algae, or cyanobacteria, which can produce deadly toxins.

The loss of these reservoirs came at the worst possible time for Tikal. In the mid- and late 800s, most of the great cities of the Maya world were already faltering under the weight of growing populations, degrading farmland, and decades of drought. Tikal simply couldn't survive the collapse of even part of its infrastructure.

But how did the reservoirs get so polluted in the first place?

Painting the walls with poison

"Color was important in the ancient Maya world," said University of Cincinnati anthropologist Kenneth Tankersley, a co-author of the study. The Maya were especially fond of paint made from a blood-red mineral pigment called cinnabar. Painters used it in colorful murals, builders painted the plaster walls of palaces and temples with it, mourners decorated ceremonial burials with it, and potters even used it to decorate ceramics.

Unfortunately for the Maya, cinnabar is poison. The pretty red mineral, which produces such lovely shades when mixed with iron oxide, is actually mercury sulfide. And Lentz and his colleagues say that over the centuries, mercury leached out of the vibrantly painted walls of Tikal's most magnificent buildings and flowed straight into its reservoirs.

It had been building up in two of Tikal's reservoirs for centuries before the city's final decline. Lentz and his colleagues found toxic levels of mercury in sediment layers dating from 600 CE to 900 CE, based on radiocarbon dating of

bits of organic matter mixed into the sediment.

“We were able to find a mineral fingerprint that showed beyond a reasonable doubt that the mercury in the water originated from cinnabar,” said Tankersley.

Rich people problems

Most of the time, polluted urban water supplies are a problem for the poor—think of the London cholera outbreak that kickstarted modern epidemiology, or modern lead pollution in the water supply of Flint, Michigan. But the reservoirs in Tikal watered the political and ceremonial heart of the city, as they resided next door to a palace complex and major temples.

“The drinking and cooking water for the Tikal rulers and their elite entourage almost certainly came from the Palace and Temple Reservoirs,” wrote Lentz and his colleagues. “As a result, the leading families of Tikal likely were fed foods laced with mercury at every meal.”

And ironically, the wealth and power that surrounded the reservoirs poisoned their waters but left the rest of the city’s water supply untouched. The plazas that drained into the Palace and Temple Reservoirs were surrounded by palaces, temples, ballcourts, and cemeteries, all decorated with murals and cinnabar-painted plaster. Two other large reservoirs in less prestigious areas of the city were mercury-free, according to Lentz and his colleagues.

Enlarge / Tikal's Central Acropolis, seen here across the city's Great Plaza, would have drained into the Palace Reservoir.

Kitchen garbage and algal blooms

Deadly blooms of blue-green algae also struck the reservoirs at the city's elite center and left more ordinary districts untouched. And that, too, is a problem Tikal's rulers accidentally created for themselves.

Based on the XRF analysis, the two reservoirs had also contained high levels of chemicals called phosphates; that usually means the waters were fouled with food waste, feces, and other organic matter. That would have made the reservoirs pretty gross, but it also provided nutrients that fueled huge blooms of blue-green algae, like *Planktothrix* and *Microcystis*.

Phosphate levels in the Palace Reservoir quadrupled between

600 and 830 CE, and it's not hard to see why. Archaeologists found the remains of an ancient kitchen at the north edge of the Palace Reservoir, where meals would have been prepared for the royal residents of the Central Acropolis, Tikal's major palace complex.

"Hundreds of years of smoky cooking fires and ceramic plates washed in the reservoir added organic material to the waters," wrote Lentz and his colleagues. "To make matters worse, the Maya cooks apparently dumped food wastes right outside of the kitchen, as evidenced by the presence of an adjacent midden. During the rainy seasons, effluent from this trash pile would have washed directly into the reservoir."

Not a drop to drink

The droughts of 820 to 870 CE left the reservoir's waters receding and stagnant—and thanks to the palace kitchens, also chock-full of phosphates and other organic matter. In other words, the reservoirs became the perfect place for cyanobacteria to thrive in deadly profusion. In those layers of sediment, Lentz and his colleagues found traces of ancient DNA from *Planktothrix* and *Microcystis* species.

Both of those types of blue-green algae produce compounds called microcystins, which get released into the water when the algae cells die. Most microcystins are toxic to the liver, but some are also neurotoxins, and they can also irritate the eyes, skin, and throat. They're deadly at very low concentrations and impervious to the usual water-purification tricks, like boiling.

"With the presence of microcystins in Tikal's reservoirs, the water could not have been safely consumed," wrote Lentz and his colleagues.

“A complex tapestry of interwoven calamities”

Even with its other reservoirs still clean, the loss of the Palace and Temple Reservoirs would have been a major blow to Tikal's infrastructure. The city had no ready access to rivers, lakes, or other water sources, and the local water table lies 200m deep, beyond the reach of ancient Maya technology. And for around 50 years, the people of Tikal endured drier, less predictable rainy seasons and harsher dry seasons, which meant the city really couldn't spare two large reservoirs.

The water pollution made life harder for Tikal's residents, who were already struggling with food shortages and other woes. It probably also had political consequences for the city's rulers, whose elaborate decorations and kitchen garbage had caused the problem in the first place.

Maya rulers were expected to provide clean water and fertile crops by keeping the gods happy. In the late 800s, the people may have taken the foul, poisoned reservoirs and the decades of drought as a sign that their rulers had failed in that all-important duty. It may have seemed that the city and its rulers had fallen out of favor with the gods, and many people may have decided there was little reason to stick around and plenty of reason to leave. By around 950 CE, Tikal was on its way to becoming picturesque ruins.

“This scenario likely played out at other Maya cities dependent on reservoirs,” wrote Lentz and his colleagues. “This study presents new methodologies that can be used to test this hypothesis elsewhere.”

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