Ecological effects of sudden drainage of large karst lakes in the Lacandon Maya region, southern Mexico

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Water levels in Lakes Metzabok and Tzibaná, two large karst lakes in the Lacandon Forest of southern Mexico, declined dramatically within a two-week period in July 2019. Lake Metzabok (0.83 km$^2$; $z_{\text{max}}$ = 25 m) dried completely, whereas in Lake Tzibaná (1.24 km$^2$; $z_{\text{max}}$ = 70 m) it fell by ~30 m. Analysis of satellite images in Lake Metzabok suggested a combined reduction in surface area of ~0.86 km$^2$ and water volume loss of ~11.7 million m$^3$. The sudden loss of such a large volume of water had negative impacts on local Lacandon Maya inhabitants, and profound ecological and environmental effects, in that it caused biodiversity loss.

We combined limnological and paleolimnological analyses to evaluate the ecological effects of the sudden loss of water from Lakes Metzabok and Tzibaná. We collected and analyzed remnant waters, surface sediments and short sediment cores from what remained of the water bodies to evaluate whether evidence for such drainage events is preserved in lake sediments. In situ water-column measurements yielded values similar to those from the previous six years when the lakes were filled, suggesting that evaporation was not the process responsible for lake level lowering, but rather that the lakes drained through fractures in the underlying karst bedrock. We collected phytoplankton and zooplankton samples from the remnant waters and found abundant diatoms, green algae, testate amoebae, crustaceans (copepods, cladocerans, ostracodes), insects (chironomids, trichopterans), colembolans, rotifers, tardigrades and nematodes. Environmental conditions in such small remnant ponds are probably stressful and unstable, but because many fish, the main predators in these ecosystems, did not survive the desiccation event, the aquatic environment is ideal for survival or recolonization by many invertebrate groups. Understanding the dynamics of this modern scenario with low lake levels is key for making paleolimnological inferences that use these aquatic bioindicators. We also investigated the commencing transition from an aquatic to a terrestrial habitat in Lake Metzabok. Abundant spiders colonized cracks in the dry sediment. Small, deep holes in surface mud were probably created by aquatic organisms when water levels decreased rapidly. Some cracks held rain water and were inhabited by tadpoles of the Gulf Coast toad (*Incilius valliceps*). The first plants to colonize the exposed lake beds belonged to the families Poaceae (grasses), Amaranthaceae (amaranths/chenopods) and Fabaceae (legumes), among others.
The sediment record from Lakes Metzabok and Tzibaná as well as testimonies of local Lacandon Maya inhabitants suggest that similar lake level lowering events occurred in the past. The hydrology of karst lakes is complex and unpredictable because multiple geological and hydrological factors control the water balance. The cause of this recent lake level lowering event remains unknown, but may be revealed by interdisciplinary studies of the limnology, paleolimnology, structural geology, geophysics, hydrology, geochemistry, genomics and geodesy of lakes and rivers in the region, as well as traditional environmental knowledge of the Lacandon Maya.

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