THE CONVERSATION
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Katwe Bay in Lake Edward (Uganda) Author

African lakes emit far less greenhouse gases than feared

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One of the keys to predicting climate change is the modelling of how greenhouse gas (GHG) emissions from natural ecosystems might evolve. This first requires estimating as accurately as possible the current GHG emissions from these ecosystems, as well as their causes.

The assessment involves a constant process of re-evaluation, with scientists having to adapt to the latest measurement techniques, theoretical frameworks and expanding databases. As computers' power increases, mathematical models grow more complex, capturing space and time representations in finer detail. This re-evaluation may be all the more important and frequent for the systems that have been the least studied up to now.

Lake emissions: a missing piece from the carbon puzzle

Rivers and lakes, which have the potential to release high quantities of carbon (CO_2) and methane (CH_4) to the atmosphere, undoubtedly form part of that latter category. While the capacity of ocean and terrestrial systems such as forests to sequester human-induced CO_2 was recognised in the late 1950s, it would take another 30 years (almost a generation of scientists!) for the role of rivers, natural lakes and dams in the carbon cycle to be acknowledged in the mid-1990s. Methane emissions from continental waters, in particular, were only estimated in the mid-2000s. This is because rivers and lakes cover a modest area - typically less than 1% of the land surface - and were therefore not regarded as important CO_2 or CH_4 emitters in the past.

Similarly, scientists until now only had measured emissions from North American and Scandinavian boreal lakes. To make up for the missing parts of the carbon puzzle, such values were extrapolated to lakes in the rest of the world – including tropical lakes. But this is about as inelegant a solution as conflating the ecology of Northern Canadian forests to the Amazonian ones.

Carbon-sucking phytoplankton … and methane-producing microorganisms

Our new study on 24 African lakes, which is published today in *Science advances* , is about to fill this gap. A collaboration between the University of Liège and scientists from KULeuven, the NAFIRRI and the TAFIRI, it reveals GHG emissions from African lakes behaved very differently from the boreal lakes sampled thus far.

For starters, the warm and luminous conditions associated with the tropical “endless summer” meant some African lakes were home to vast quantities of phytoplankton. These micro-algae remove CO2 from the water thanks to the process of photosynthesis.

Such observations invalidate our assumption based on boreal lakes that African counterparts emitted CO2. Due to cooler and darker conditions, lakes in North America and Scandinavia grow very little phytoplankton and limit themselves instead to “composting” the vegetation debris from the surrounding forests.

Their African counterparts, in contrast, are CO2 sinks.

But the warm tropical conditions have a downside. Indeed, heat is favorable to *archaea*, a category of microorganisms resembling bacteria that produces methane. The latter also happen to particularly enjoy feeding off the phytoplankton that sink to the bottom of tropical lakes. As a result, methane concentrations were shown to be much higher in African than boreal lakes, and what is “gained” in tropical lakes by sequestering CO2 is “lost” by emitting CH4.

Why do certain African lakes emit more than others?

CO2 and CH4 content also varied widely between the 24 lakes based on water depth and colour.

The shallowest of the sampled African lakes was home to the highest biomass of phytoplankton, therefore hosting the lowest CO2 and the highest CH4 concentrations. In shallow lakes, surface waters, which receive the sunlight necessary for photosynthesis, are at the same time in direct contact with the bottom sediments. The bottom sediment provide nitrogen and phosphorus nutrients are also needed for plant growth - like fertilizer in the garden, leading to optimal growth conditions.

Some types of phytoplankton, such as the heat-loving cyanobacteria, also boast physiological features that allow them to reach much higher densities than other micro-algae. Furthermore, proximity to sediments also explains the high CH4 concentrations in shallow lakes.

Local fishermen help scientists measure CO_2 emissions on Lake George in Uganda. Author

Our second factor to determine phytoplankton and biomass growth, water colour, depends on the vegetation cover surrounding the lakes. To help yourself visualise this, recall how the puddles you see on a walk in the forest have a tea-looking, brown colour. This is due to the presence of dissolved substances called humic which absorb light and prevent the development of phytoplankton.

Tropical forests bordering African lakes, with their rich soils, are full of the stuff. Conversely, lakes surrounded by savannah in more arid regions of Africa had less humic substances. Their clearer waters allowed the growth of phytoplankton, and thus in this case sequestrated more CO_2.

25 times less CO_2 emissions than previously assumed

Finally, the study drew from a recent spatial database detailing the surface and depth measurements of 72,500 tropical lakes worldwide. An understanding of the mechanisms underlying the production of CO_2 and CH_4 by lakes (depth and surrounding vegetation cover) allowed for an “informed” rather than a “blind” statistical extrapolation of the data based on a simple average of all the data.

Prior studies assumed tropical lakes emitted up to 1600 mega tons of CO_2 per year, equivalent to 40% of global CO_2 emissions linked to deforestation or the cumulated emissions of CO_2 from Germany, UK, France and Italy. Our research suggests that tropical lakes in fact emit CO_2 at a rate 25 times lower.

In conclusion, our research brings good news: until now it was assumed lakes emitted high volumes of CO_2 - notwithstanding the modest surfaces they covered. Such beliefs were based on data from lakes in North America and Scandinavia, however, regions where the climate and vegetation cover are conducive to high lake CO_2 emissions. In contrast, GHG emissions from tropical lakes are low and had been largely overestimated until now.

The bad news is that because methane producing archaea love warm conditions, future warming of tropical lakes might lead to an increase of CH_4 emissions to the atmosphere. Something to keep under surveillance.

This study synthesizes measurements obtained over more than 10 years in 24 African lakes including the largest of the African Rift (Victoria, Tanganyika, Albert, Kivu, Edward), during 17 field expeditions, in the framework of 2 BELSPO projects (EAGLES, HIPE) and 5 FNRS projects (TRANS-CONGO, LAVIGAS, TANGAGAS, KYBALGAS, MAITURIK).