Lakes triple amount of carbon they bury in response to human disruption of global nutrient cycles

April 28 2020

Sediment core. Credit: Loughborough University

A new study led by Loughborough University has revealed that lake burial of organic carbon has increased three-fold over the last 100 years in response to human disruption of global nutrient cycles.

Professor John Anderson, of the Geography and Environment department in the School of Social Sciences and Humanities, hopes the findings will expand our understanding of global carbon storage and the role lakes play in this, as the burial process was previously considered not important.

The research, published in *Science Advances*, was undertaken in an attempt to account for some of the gaps in the global carbon budget.

The global carbon budget looks at the amount of carbon produced on a global scale and where it ends up.

In theory, the amount of carbon released by human activities—such as burning fossil fuels and chopping down trees—and the amount of carbon taken up by oceans, soils and the atmosphere, should balance.

However, the numbers do not quite add up and part of the budget is considering 'missing' as we are unable to account for where some of the carbon has gone.

This is an issue as balancing the budget is an important part of understanding the contemporary carbon cycle, which scientists analyze to predict future levels of carbon dioxide in the atmosphere and its

greenhouse effect.

Though it is known that all lakes bury carbon, little attention has been paid to this fact and previous lake studies have only considered how carbon is transferred from land to the water.

Professor Anderson's research, which is in collaboration with Dr. Adam Heathcote and Dr. Daniel Engstrom, of the Science Museum of Minnesota (SMM), and the Globocarb consortium (a team of 20 academics from institutions around the world), is the first study to explore whether lake carbon burial rates have increased over the last 100 years across the globe.

Lakes bury carbon as organic matter—matter that has come from a recently living organisms (for example, decomposing aquatic vegetation), which is roughly 50 percent organic carbon.

The matter sinks to the bottom of lakes and remains there as a brown-looking sludge. Oceans and estuaries also bury carbon—but not as much as lakes in relative terms.

To assess how burial rates have changed over time, Professor Anderson and the research team looked at sediment cores taken from 516 natural lakes across the globe.

As well as looking at data and samples from different countries and continents—including the UK, South America, Sweden, Denmark and Canada—they also looked at lakes in Earth's different vegetation zones—known as 'biomes'—such as the rainforest, savannah and tundra.

Professor Anderson and the team calculated the age of the sediment cores using radiometric dating (^{210}Pb)—a technique used to date materials based on the known decay rate of the radioactive elements they

contain—and they also calculated the organic content of the sediment.

Their approach was particularly novel as they used an enhancement of the ^{210}Pb dating method that acts as a focusing correction.

This method allowed them to standardize the burial rate across all lakes—which is important as lakes vary in size and sediment is not distributed uniformly—and then calculate how much organic carbon is buried by all lakes in one geographic area.

From their analysis, the team found:

- The total global carbon burial rate by lakes has increased from 0.05 PgC yr-1 to 0.12 PgC yr-1 (where 1 petagram (Pg) of carbon (C) is equivalent to 1 billion metric tons of carbon, or 3.67 billion metric tons of CO_2) over the last 100 years
- Across all biomes, burial rates have tripled, including four-fold increases in lakes in tropical grasslands and forests—which reflects the high level of human disturbance in the tropics during the 20thcentury
- Lakes in the boreal biomes (forest areas of northern Eurasia and northern North America) contribute to the largest proportion of global carbon burial rate due to their large coverage, but they are closely followed by lakes in tropical forests and then lakes located in grasslands and the savannah.

The team also found that the increase in burial rates is largely in response to the major physical transformation of the Earth's surface over the last 100-200 years.

Forests play a huge role in the carbon cycle and when they are cut down, not only does carbon absorption cease, but the carbon stored in the trees is released into the atmosphere through burning or decomposition.

Human activity in the 1950s resulted in rapid land-cover changes and the removal of forests, massively impacting the carbon cycle.

The researchers found most biomes increased lake carbon burial from the late 19th century onwards, meaning lakes were responding to these major changes in the earth's biogeochemistry.

As well increasing burial rates to offset land-based carbon emissions, the researchers also found that human disruption to the nitrogen cycle and other nutrient cycles impacted burial rates.

Fertilizers and nutrient additives are used in farming to help crops grow and they often enter lakes and streams through runoff and soil erosion.

The same nutrients that help crops grow also increases the growth of aquatic plants, which in turn increases the amount of decaying plant matter in lakes and therefore the amount of buried carbon.

The team found in areas with intensive agricultural and substantial nutrient subsides through fertilizer use—such as areas that were mixed forests and grasslands in Europe and North America prior to land use changes—lake burial rates have increased three-fold since the start of the 20th century.

Of the research, which is shared in a paper titled "Anthropogenic alteration of nutrient supply increases the global freshwater carbon sink,"Professor Anderson said: "Carbon burial in lakes is a sink in the context of the modern carbon cycle, it can be thought as offsetting the effects of anthropogenic CO_2 release.

"I hope this research makes people aware that burial rates are an important part of the linked terrestrial-aquatic carbon cycle and that rates have increased.

"It also highlights that climate change is not a significant component of this increased burial rate, it is mainly land-use and associated changes in nutrient use that are the main drivers."

Professor Anderson hopes to build on this research by better constraining the burial rates in the Arctic—an area with many lakes but which is relatively understudied.

This study found carbon burial rates to be low in Artic lakes, but the rates may increase rapidly in the future as a result of melting permafrost (ground that remains permanently frozen) and this is important given the Arctic is where much of the earth's organic carbon is stored.

More information: N. J. Anderson et al. Anthropogenic alteration of nutrient supply increases the global freshwater carbon sink, *Science Advances* (2020). DOI: 10.1126/sciadv.aaw2145

Provided by Loughborough University