Rivers and streams in the Andean Cordillera are hot spots for greenhouse gases emissions, shows study

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Credit: University de Liege

A new scientific study by researchers from the University of Liège (Belgium) shows that rivers in the Andean mountains contribute 35% and 72% of riverine emissions of carbon dioxide (CO_2) and methane (CH_4) in the Amazon basin, the world's largest river. This study is

published in the journal *Communications Earth & Environment*.

Rivers contribute substantially to global emissions of carbon dioxide (CO_2) and methane (CH_4). The Amazon River, the World's largest river, plays an important role in greenhouse gas (GHG) emissions. "It is the largest river on the planet in terms of freshwater flow," explains Alberto Borges, FNRS Research Director at the FOCUS Research Unit at the University of Liège.

"We are talking about a discharge of 6,600 cubic kilometers of water per year. It is also the largest hydrographic basin with a surface area of 6,300,000 km^2, which is comparable to the size of the United States of 9,834,000 km^2. In addition, the Amazon River drains the largest rainforest on the planet, which provides rivers with large amounts of organic carbon that is transformed by microbes into CO_2 and CH_4, and then emitted across surface waters into the atmosphere."

The Amazon River originates (headwaters) in the Andes Mountains and flows through Peru, Colombia, Ecuador and Brazil to the Atlantic Ocean. The erosion of rocks at the river's headwaters in the Andes is the main source of mineral particles that are transported about 3,000 km across the South American continent to the river's mouth at Belem, Brazil, where they flow into the Atlantic Ocean.

"All the studies on CO_2 and CH_4 emissions to the atmosphere by Amazon rivers have been carried out so far in the plains of the central Amazon, at least 1,000 km from the Andes," says Alberto Borges, "whereas mountain rivers show very different rates of CO_2 and CH_4 emissions from those of lowland rivers."

Lowland rivers and mountain streams

There are three river systems nested in mountains and spread across

plains. The first, the mountain stream, is small and flows rapidly over steep, rocky terrain. This promotes a vigorous physical exchange of gases with the atmosphere. In contrast, steep terrain does not allow for a large accumulation of soils that support the production of CO_2 and CH_4.

The second system, the lowland river, is wide and winding, and spreads over flat terrain. The slower flow of water does not promote the physical exchange of gases with the atmosphere as vigorously as in mountain rivers. However, the higher temperature (lower altitude) allows for more vegetation (forests) to grow and the flat terrain allows for thicker soils to accumulate than in the mountains. This should favor the production and transport of CO_2 and CH_4 to lowland watercourses.

Finally, the flat terrain favors the development of floodplains connected to lowland rivers, which also supply the rivers with CO_2 and CH_4.

"There is a third type of river system," explains Gonzalo Chiriboga, a doctoral student in the Chemical Oceanography Unit and first author of the article. "Located in the plains at the foot of mountain ranges, it is called a 'piedmont river'. From a physical point of view, these rivers resemble lowland rivers, but they receive massive amounts of particles from mountain rivers located upstream. These particles are temporarily deposited, then resuspended and transported further downstream until they reach the ocean."

And when the particles are deposited as sediment, this promotes the production of CH_4 through fermentation. So, figuratively speaking, piedmont rivers can be compared to CH factories.

Based on these theoretical considerations, we would expect CO_2 and CH_4 emissions to be very different in mountain, piedmont and lowland rivers. "CO_2 and CH_4 emissions have so far only been measured in lowland rivers in the central Amazon," the young researcher continues,

"so we were missing potentially important pieces of the puzzle, which is crucial for the largest river on the planet."

One issue has now been addressed in the article that is published in *Communications Earth & Environment*, which presents data on Ecuador's mountain and piedmont rivers along an elevation transect ranging from 175m to 3990m. "We found that mountain rivers in the Andes have higher emissions than piedmont rivers, and are hot spots for CO_2 and CH_4 emissions, with significantly higher flux intensities than in the lowland rivers of the central Amazon."

The study shows that, together, streams and rivers in the headwaters and piedmont of the Andean mountains account for 35% of CO_2 and 72% of CH_4 of integrated riverine emissions at the basin scale.

More information: Chiriboga G. et al, Andean headwater and piedmont streams are hot spots of carbon dioxide and methane emissions in the Amazon basin, *Communications Earth & Environment* (2023). DOI: 10.1038/s43247-023-00745-1
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