Study finds 21st century mining boom across the tropics is degrading rivers

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Shallow mining ponds overwhelm a former river system in the La Pampa region of Madre de Dios, Peru. The colors of the ponds reflect suspended sediment and algae growth following the cessation of gold mining. Credit: Jason Houston (iLCP Redsecker Response Fund/CEES/CINCIA)

Gold and mineral mining in and near rivers across the tropics is degrading waterways in 49 countries, according to a Dartmouth-led study. Published in *Nature*, the findings represent the first physical footprint of river mining and its hydrological impacts on a global scale.

River mining often involves intensive excavation, which results in deforestation and increased erosion. Much of the excavated material is released to rivers, disrupting aquatic life in ecosystems nearby and downstream. This inorganic sediment, particles of clay, silt, and sand, is carried by rivers as "suspended sediment," transmitting the environmental effects of mining downstream.

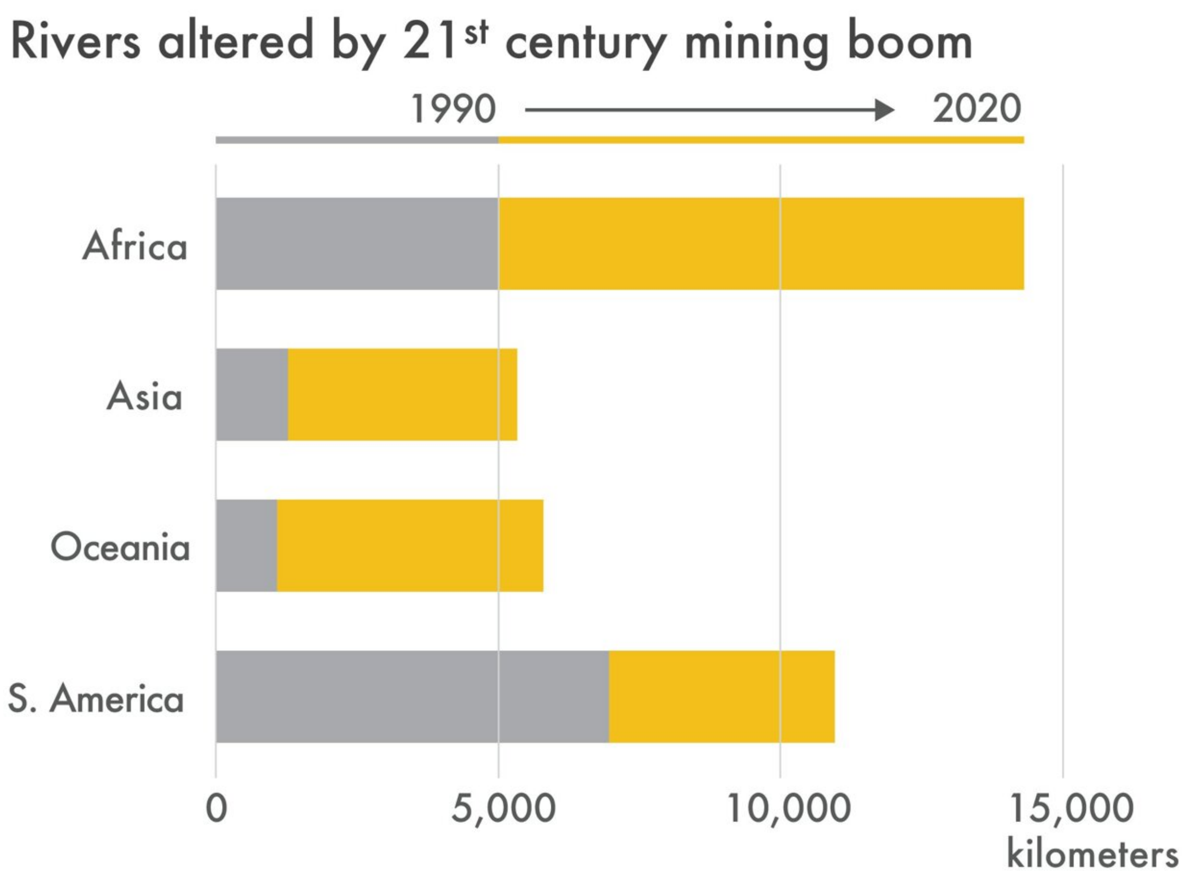
Prior research has reported that such suspended sediment may also carry toxins such as mercury used in river mining processes, which further affects water quality and can be detrimental to human health and the environment.

"For hundreds, if not perhaps, thousands of years, mining has been taking place in the tropics but never on the scale like we've seen over the past two decades," says first author Evan Dethier, an Occidental College assistant professor, who worked on the study while he was a postdoctoral researcher at Dartmouth. Dethier has a Ph.D. and MS in earth sciences from Dartmouth's Guarini School of Graduate and Advanced Studies. "The degradation of rivers from gold and river mining throughout the tropics is a global crisis."

For the first part of the study, Dethier and fellow researchers conducted a comprehensive analysis of river mining across the tropics from 1984 to 2021. They analyzed information from the media and literature, mining company reports, social media, and satellite imagery from Lands at 5 and 7 via the NASA/United States Geological Survey Landsat program and Sentinel-2 data, and aerial images from public sources.

They recorded over 7.5 million measurements of rivers around the world to map mining areas, and deforestation and sediment impacts. They also identified target minerals at the mining sites.

The results show that there are approximately 400 individual mining districts in 49 countries across the tropics. More than 80% of the mining sites are located within 20 degrees of the equator in South America, Africa, Asia, and Oceania.



Rivers altered by 21st century mining boom. Credit: Evan Dethier.

The team found a major uptick in mining in the 21st century, with the emergence of mining at 60% of the sites after 2000, and 46% after 2006, coincident with the global financial crisis. This increase in mining continued even through the COVID-19 pandemic.

For the second part of the study, the researchers assessed the magnitude that mining operations have had on the amount of suspended sediment in 173 affected tropical rivers. To detect the transport of suspended sediment using Landsat data, the team applied algorithms that they developed during the past seven years.

The data shows that more than 35,000 kilometers of tropical rivers are affected by gold and mineral mining around the world. Of the 500,000 kilometers of tropical rivers worldwide, about 6% of that length is affected by such mining.

Furthermore, mining has caused suspended sediment concentrations to double at 80% of the 173 rivers represented in the study, relative to pre-mining levels.

"These tropical rivers go from running clear either throughout the year or at least through part of it, to either being choked with sediment or muddy year-round," says Dethier. "We found that almost every single one of these mining areas had suspended sediment transmitted downstream, on average, at least 150 to 200 kilometers (93 to 124 miles) from the mining site itself but as much as 1,200 kilometers (746 miles) downstream."

Shallow mining ponds dominate the landscape where a stream once ran through the rainforest in the La Pampa region of the Madre de Dios, Peru. The degraded streams now carry waste sediment from these mining ponds downstream. Credit: Jason Houston (iLCP Redsecker Response Fund/CEES/CINCIA)

"To give you an idea of how far the sediment can travel downstream, this is nearly comparable to the distance from Bangor, Maine, to Richmond, Virginia," says Dethier.

There are 30 countries that have both active river mining operations and large tropical rivers that are more than 50 meters wide. In those countries, on average, 23% of the length of their large rivers is affected by mining. In some countries, more than 40% of the total length of those large rivers is altered by mining, including in French Guiana (57%), Guyana (48%), and Cote d'Ivoire and Senegal (40%).

The study also included rivers such as the Congo in Africa, the Irrawaddy in Asia, the Kapuas in Oceania, and the Amazon and Magdalena in South America.

"Many of these tropical rivers systems are very biodiverse places, if not some of the most biodiverse places on Earth and are still currently understudied," says senior author David Lutz, a research assistant professor of environmental studies at Dartmouth. "The challenge here is that there are many species that could potentially become extinguished before we even knew that they existed."

To evaluate the ecological impact of river mining in the tropics, the team examined environmental management guidelines used in the U.S. and elsewhere and applied the standards to their data.

Since mining began, they found that two-thirds of the rivers represented in the study exceeded the turbidity guidelines for protecting fish on 90% of the days or more, meaning the cloudiness of the rivers was higher than recommended.

"When rivers and streams experience high levels of suspended sediment, fish are unable to see their prey or predators and their gills may become choked with sediment and damaged, which can lead to disease or even mortality," says Lutz.

"Our team's prior work has reported on how gold mining is a problem in the Madre de Dios region of the Peruvian Amazon, by poisoning wildlife and people," says co-author Miles Silman, the Andrew Sabin Family Foundation Professor of Conservation Biology, and president of Wake Forest University's Centro de Innovación Científica Amazónica (CINCIA).

"While gold mining has a lot of potential to lift people out of poverty, particularly on remote tropical frontiers, the way it is done now comes at a tremendous societal cost from environmental degradation, mercury pollution, and corruption and criminal networks."

While gold is the principal target for miners and accounts for nearly 80% or more of the mining sites, mining along rivers in central and west-central Africa, particularly, in Angola, the Democratic Republic of the Congo, and Cameroon, makes diamonds the second most mined mineral in the tropics. In addition, other precious minerals are also mined. In southeast Asia, nickel is mined in Indonesia, the Philippines, and Malaysia.

Many minerals that are used in cell phones and electric-car batteries and are used in electronics, such as cobalt, coltan, tungsten, and tantalite, are mined in the Democratic Republic of the Congo.

"These minerals are becoming increasingly necessary as we transition away from fossil fuels to clean energy," says Dethier. "So, this is an important area to keep track of."

The co-authors call on government policymakers to work with stakeholders to help mitigate the environmental and social impacts that mining is having on tropical rivers given that it's likely to continue into the foreseeable future.

More information: Evan Dethier, A global rise in alluvial mining increases sediment load in tropical rivers, *Nature* (2023). DOI: 10.1038/s41586-023-06309-9.
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