News & views

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Figure 1 | The impact of river mining in La Pampa, Peru. Anomalously high sediment concentrations have been detected in tropical rivers near mining activity around the world.

Environmental science

Images show the impact of mining on tropical rivers

Bryony Walmsley

A careful analysis of satellite images has revealed marked changes in the suspended-sediment concentrations of many rivers around the world. The study links these changes directly to river mining activities in the affected areas. **See p.787**

Less than 1% of water on Earth is both fresh and in liquid form, and about two-thirds of this water lies underground[1]. Climate change, deforestation and rapid urbanization all threaten the remaining surface water, as do increasing population pressures and changes in land use, so news that river mining has a pronounced effect on this resource comes as a shock. On page 787, Dethier *et al.*[2] report that some 35,000 kilometres of large tropical rivers (those that are more than 50 metres wide) have been severely affected by sediment from river-mining activities (Fig. 1). An estimated 24,000 kilometres of smaller rivers are also affected, bringing the length of mining-affected water courses to a total that would stretch almost one and a half times around the Equator.

The banks and floodplains of rivers have been mined for gold, diamonds and other precious minerals for centuries. Dethier *et al.* hypothesized that these practices, together with associated deforestation, increase the concentration of sediment suspended in the water, and that the changes start to occur as soon as the activity begins. To confirm this hypothesis, the authors focused on gold mining, and monitored changes in concentrations of suspended sediment in rivers by analysing satellite images captured over several decades (Fig. 2). One of the benefits of using such a long-term database is that the sediment concentrations in the rivers before, during and (in some cases) after mining could be determined. In almost all cases, the authors concluded that sediment concentrations increased

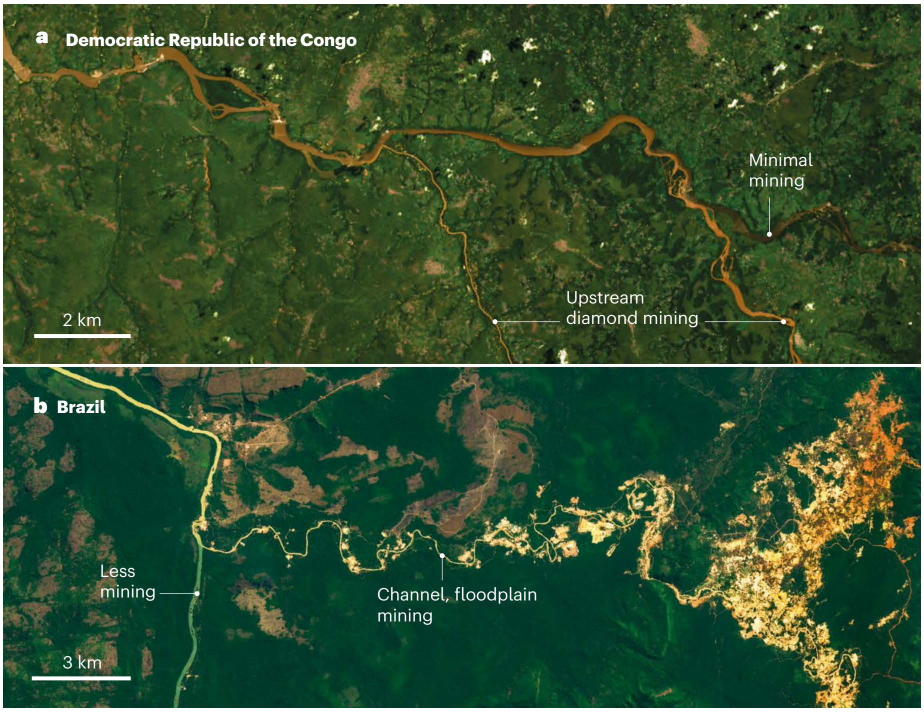

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Figure 2 | River mining increases levels of suspended sediment in rivers. Dethier *et al.*[2] used satellite images such as these to analyse the impact that river mining has on tropical rivers around the globe. They showed that suspended-sediment concentrations increased immediately after the onset of mining in most of the rivers that they studied, including in the Democratic Republic of the Congo (**a**) and Brazil (**b**). (Adapted from Fig. 4b and Fig. 4f of ref. 2.)

immediately after the onset of mining.

To conduct their analysis, Dethier *et al.* used algorithms that were calibrated with the help of monitoring data that already existed for some of the rivers in their study. In most cases, however, their image-based approach was the only viable option owing to the lack of long-term monitoring data. Although the authors admit that their algorithms are imperfect, they were able to demonstrate that field measurements of sediment concentrations were consistent with their satellite-derived estimates.

The transport of sediment in rivers is a natural process that is crucial for maintaining the shape and functioning of rivers – especially of river mouths, estuaries and deltas[3]. However, the elevation of a river's sediment concentration to a level that is several times higher than its natural concentration can result in several negative effects, particularly for aquatic organisms. The decreased water clarity restricts the penetration of light, and elevated sediment loads can clog fish gills and alter aquatic habitats. Dams and weirs can also be affected: high rates of sediment deposition reduce their storage capacity, thus compromising flood-prevention measures and diminishing the output of hydropower operations.

These damaging effects are exacerbated by the use of mercury and cyanide in gold-ore processing, and by other contaminants from operations associated with mining copper, cobalt, diamond and other minerals. Such contaminants attach themselves to the fine particles that are released into rivers during mining activities, and can pose a huge risk to human health and that of aquatic organisms – even tens of kilometres downstream from where the mining takes place. Although there are reports of decreased water quality downstream of mining operations[4–9], few have investigated the correlation between sediment concentrations, metals and the direct and indirect effects on the health of humans and other organisms.

A question that springs to mind immediately is how it is possible to attribute the increased sediment concentrations to river mining alone, without considering the effects of deforestation, farming activities, infrastructure development and urbanization. The authors answered this question, in part, by analysing 33 rivers with high sediment concentrations in catchments with extensive oil-palm plantations, which have been shown to increase sediment yield from affected catchments in the tropics[10,11]. They found that sediment concentrations increased immediately after mining commenced, and that the increases were markedly higher than those typically associated with plantations. This result confirms that mining is the main reason for increased concentrations of suspended sediment in these catchments.

Dethier and colleagues' study documents the widespread occurrence and pervasive detrimental effects of river mining around the world, particularly in the tropics. This form of resource exploitation is underappreciated, so the authors make a crucial contribution to our understanding of the impacts of river mining by quantifying the extent, magnitude and consequences of the problem. However, the work highlights the need for future research into the complex socio-economic impacts of river mining, deforestation and the effects of our quest for a greener future. Other directions for further investigation could include considering how climate change is affecting sediment transport by increasing the magnitude and frequency of heavy rainfall events.

Although Dethier *et al.* focused on gold mining, which occurs in 90% of the areas that they catalogued, there is also scope for expanding their research to understand the effects of the full life cycle of other minerals – especially those needed for green-energy projects. Green technologies and the semiconductor industry have together prompted a mining boom for a range of minerals in the past two decades, to which mining operations have responded by increasing their activity. These operations can be on a small scale, because they do not require land rights and substantial capital investments, but large corporations also engage in river mining, usually on a much bigger scale. Unfortunately, most tropical river mining takes place in countries with limited control or enforcement of environmental and social safeguarding laws, and proceeds unhindered by such requirements.

Dethier and colleagues' meticulous study is a first step towards quantifying the magnitude of the problem caused by these circumstances. Their efforts lay the groundwork for future investigations, and show that using carefully calibrated algorithms to analyse satellite images offers a robust route to quantifying the devastating impact of mining on tropical river systems.

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The author declares no competing interests.

Correction

The caption for Figure 1 in the News & Views article entitled ‘Images show the impact of mining on tropical rivers’ erroneously stated that the photo was taken in Argentina. It was taken in Peru.

Corrected: 11 September 2023