Urbanization and agriculture are land uses that most affect Brazil's rivers

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A literature review by researchers affiliated with universities in Brazil and the United States produces the first ever nationwide survey of land use impacts on water quality, showing how a lack of planning may affect the availability of a natural resource that is already becoming scarce Toxic foam over Tietê river waters at Salto, Brazil. Credit: Eurico Zimbres, Wikimedia Commons

Brazil has more freshwater than any other country, but this resource is dwindling because of climate change, rising consumption and inadequate treatment, among other factors. Worse, Brazil's rivers are increasingly polluted due to a lack of proper land use planning.

Agriculture and urbanization are the main culprits, closely followed by mining. Although mining occupies a small percentage of Brazil's territory, it has a huge impact on water quality, according to a literature review by a group of researchers published in *Journal of Environmental Management*.

The review was led by Kaline de Mello, a biologist at the University of São Paulo's Institute of Biosciences (IB-USP). Mello is supported by São Paulo Research Foundation—FAPESP .

Researchers affiliated with the Federal Universities of the ABC (UFABC), Minas Gerais (UFMG) and São Carlos (UFSCar) in Brazil and the University of Massachusetts (UMass Amherst) and Oregon State University (OSU) in the United States also participated.

This study is the first to provide a nationwide overview of the impact of land use on water quality. "Most research offers projections of the impact of land use changes on the amount of water available and not on water quality. We set out to see what water quality will be like 30 years from now," said Ricardo Hideo Taniwaki, a professor at UFABC and a coauthor of the published article.

The authors evaluated the impacts of all possible future scenarios, ranging from worst-case to best-case scenarios for the impact of changes in land use on water quality while also considering climate change.

Extensive survey

The analysis was divided into stages. First, having collected land use and land cover data from the platform Mapbiomas, the researchers observed conservation of native vegetation and the extent of activities potentially affecting water quality, particularly agriculture, pasture, silviculture (forestry), mining and urbanization.

"Next, we separated the field studies that assessed the effects of the activity in question on nearby rivers in the various Brazilian biomes," Mello said. The parameters used to measure water quality included fecal bacteria, sediment, nitrogen, phosphorus, heavy metals, and other pollutants.

The second stage showed that degradation varies according to the scale or dimension used to evaluate it and that this should be taken into account when conservation action is planned. Land use impacts on water quality are evaluated in one or all of the following spatial dimensions: at the water sampling site, in the riparian vegetation and in the entire catchment area. "Catchment analysis appears to best reflect overall water quality," Taniwaki said.

The temporal dimension involves rainfall and other seasonal variations, such as temperature. "This is important in the context of climate change," Taniwaki said. "Heavier precipitation and longer droughts are expected. In the absence of best agricultural practice, river pollution will increase."

Finally, the article discusses mathematical models that predict future water quality. "We highlight models available in Brazil that can be used to simulate the impact of positive and negative measures, as well as the data required to do so," Mello said.

Impact by soil type

Pasture and cropland account for 28.8% of the territory and are found mainly in the Cerrado (42% of the total) and Atlantic Rainforest (62%) biomes. "In areas of pasture, soil compaction by animals affects water absorption. Surface runoff increases, and so does the volume of polluted water entering streams and rivers when it rains," Mello said.

Agricultural activities also affect runoff dynamics and increase the amount of pollutants such as nitrogen, phosphorus and other chemicals in water courses. "It's worth recalling that Brazil is one of the world's largest consumers of fertilizer and agrochemicals, which have a significant impact on surface water and groundwater," Mello said.

In urban areas, there are two main problems. "The soil is almost entirely sealed and made impervious by concrete and tarmac, so that runoff with pollutants of all kinds including heavy metals enters the water courses when it rains, and Brazil has few stormwater treatment programs," Taniwaki stated.

Although urban areas occupy only 0.6% of Brazil's land mass, cities are major drivers of water quality degradation due to untreated sewage, which fills rivers with fecal bacteria, organic matter and other pollutants. Some 48% of the population is not connected to a domestic sewerage network, and only 10% of the largest cities treat more than 80% of the domestic and industrial waste they collect.

Mining also occupies a small percentage of the territory but has an enormous local impact on water quality, discharging heavy metals that are toxic to plants and animals as well as humans into water courses. This impact was evidenced by catastrophic tailings dam failures in Mariana and Brumadinho, in the state of Minas Gerais.

The Mariana disaster polluted more than 650 km of the Doce, one of Brazil's major rivers, affecting over 1 million people. Analysis of water

from Paraopeba, one of the rivers affected by the Brumadinho disaster, showed that after the accident, levels of lead and mercury were 21 times those acceptable.

"More than 40 mine tailings dams are at risk of similar accidents up and down the country," Taniwaki said.

Most endangered biomes

Loss of native plant cover is the main threat to water sources in all biomes, Mello noted, citing the state of rivers and streams in the Atlantic Rainforest biome, where 65% of the population lives. Only 26% of the original vegetation remains in this dwindling biome, and water quality is considered good in only 6.5% of its rivers.

The Amazon biome and the Cerrado are also cause for concern. Although much of the Amazon's native vegetation is still in place, it is distinctly endangered. "In 2019, the Amazon suffered its greatest forest cover loss in ten years, according to the National Institute for Space Research [INPE]," Mello said.

Deforestation in the region grew 108% in January 2020 compared with the same month of 2019. Only 19% of the original vegetation survives in the Cerrado. "More research is needed on water quality in these two biomes, which are suffering the most from the advance of the agricultural frontier," Mello said.

The future of water in Brazil

Public administrators and researchers can use the mathematical models available in the literature to predict future water quality in their regions and help make a decisions on the kind of intervention that will be most

effective to deal with the specific situation. One of the tools highlighted in the article is multicriteria assessment, an approach that uses participation by civil society and private enterprise to partner with the state in prioritizing areas to be restored at a time of financial austerity.

The quality of the available data must be improved in order for this analysis to be performed more assertively, but the researchers also argue that the quantity is insufficient and that far more data are needed. "It's hard to make predictions with the water quality and land use data we have now, and predictions are vital to public policy formulation," Taniwaki said.

"The estimates now available point to severe water quality degradation unless deforestation is halted and basic sanitation improves in the years ahead," declared Mello. The long-term negative consequences include increased public spending to treat polluted water before it is used or to transport it from more distant areas. This extra cost will have to be passed on to consumers in their water bills. Drastic changes in the other environmental services provided by rivers will also be required.

"On the other hand, simulations of restoration in Permanent Conservation Areas [APPs in Portuguese, mainly riparian forest] resulting from compliance with the Brazilian Forest Code point to increased water quality due to a reduction in sediments, nitrogen and phosphorus," according to Mello.

Hence, it is important to enforce environmental legislation and planned agricultural and urban expansion. "The literature we reviewed also shows the negative effects of lowered standards, watered-down legislation, and less investment in research," Taniwaki said.

More information: Kaline de Mello et al, Multiscale land use impacts on water quality: Assessment, planning, and future perspectives in Brazil,

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