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Letter To The Editor

Eight years after the Fundão tailings dam collapse: chaos on the muddy banks

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Eight years have passed since Brazil's worst environmental disaster, the collapse of the Samarco company's Fundão tailings dam in Mariana, Minas Gerais, Brazil. The mud spill buried the village of Bento Rodrigues and affected, with mud full of heavy metals and metalloids, more than 600 km of the river channel, and marginal habitats. It extended for hundreds of kilometers along the coast, disturbing the sea, coral reefs, mangroves, and beaches (Fernandes et al. 2016; Costa et al. 2022). At the time of the disaster, more than one million people across 35 cities were affected due to the spill of around 50 million m^3 of mud waste, resulting in 19 deaths, diseases, and hundreds of people displaced (Fernandes et al. 2016; Omachi et al. 2018).

The dam breach unleashed a cascade of health and social woes for people living in the area. High levels of heavy metals were found in the blood and urine of riverside populations (Paulelli et al. 2022). There was an increase in diseases arising from habitat degradation, when people are exposed to mosquitoes, such as dengue's transmitters, as well as enteric pathogens in the water along the Doce River (Nishijima and Rocha 2020). Finally, the livelihoods, health, and culture of indigenous peoples, such as the Krenak, Tupiniquim, Guaranis, and Quilombola populations (afro-descendant communities, predominantly composed of the rural and urban black population) were profoundly affected by the disaster (Oliveira et al. 2020; Zhouri and Pascoal 2022).

The ecological devastation mirrored the human tragedy (Fig. 1). Approximately 346 endangered species on the mainland were negatively impacted by the disaster (Knopff et al. 2020), and increased the risk of extinction of 13 aquatic species, becoming a major threat to three of them (Drummond et al. 2021). Furthermore, there were unexpected impacts such as the bioaccumulation of pesticides in endangered Franciscana dolphin [*Pontoporia blainvillei* (Gervais & d'Orbigny, 1844)], as the mud tsunami stirred up historic deposits of these pollutants from soil and river sediments (Nascimento et al. 2022).

Figure 1. Dead fish in Marliéria, Minas Gerais, Brazil, about 200 km downstream from the Fundão tailings dam. Photo credit: Elvira Nascimento.

To make it worse, heavy summer rains re-suspend contaminants in the continent, while winter cold fronts suspend pollutants from the bottom of the sea every year (Fernandes et al. 2022).

Another major concern is invasive alien species. Studies have shown that changes in the substrate and water quality altered the composition of the assemblage of fish, copepods, and rotifers, favoring non-native species from these groups (Programa de Monitoramento da Biodiversidade Aquática 2021). Furthermore, another indirect impact of contamination on lake communities was the invasion of water hyacinth (*Eichhornia* sp.), which increased in lakes and ponds, with a high correlation with increases in the concentration of vanadium, iron, and zinc found in the water (Programa de Monitoramento da Biodiversidade Aquática 2021).

Finally, it is worth highlighting the challenge of restoring ecosystems. Removing all the waste that has spread throughout the basin is practically impossible, but the longer the recovery actions take, the greater the risk that the river will be contaminated again by the mud that is still on the banks, especially during periods of rain. To prevent this from happening, the recovery of the riparian forest must be prioritized. For now, emergency actions are being undertaken to try to prevent the mud from flowing into the river, with the planting of grasses and legume trees that would have the function of keeping the land on the bank firmer. However, many of these species are exotic (personal observation) and this brings future environmental problems, unbalancing the entire ecosystem. Even the use of native species can be problematic because by introducing a limited number of species into a given region, we can inadvertently reduce the ecological functionality of the environment, making it more homogeneous and less diverse (Pereira et al. 2024; Toma et al. 2024). Therefore, the restoration of vegetation in the Rio Doce basin needs to be carried out with a diverse range of native species so that environmental connectivity and restoration of the important ecosystem services on which we depend are more quickly promoted (Pereira et al., 2024; Ramos et al., 2024; Toma et al. 2024).

Specific efforts to compensate for socio-environmental impacts have been made by Renova since 2016, a foundation created to repair and compensate for the impacts of Fundão. The foundation has been building housing, compensating residents, and trying to help the affected human populations. However, the process has been very slow and controversial (Losekann and Milanez 2023). Conveniently, the company creates its foundation to repair its own damages. The government should be imposing several measures to solve the problems, demanding reports, assessments and results on what should be done. In other words, it is not right that the company chooses its own professionals to assess these damages. This oversight should be impartial and carried out by the government. Local representatives, research institutions, and NGOs should also have a say in what Renova is doing. It is of utmost importance to develop and implement a comprehensive program to provide the necessary assistance to affected families, in addition to implementing a comprehensive restoration and recovery program that would accelerate efforts and go beyond punctual efforts.

All mitigation measures may be wasted if the causes of such catastrophes are not addressed. The Mariana accident was repeated in Brumadinho, claiming 272 lives (Vidal et al. 2024). This brought to the fore the discussion about the need to find alternatives for mining activities in the country, which has 839 tailings dams (Agência Nacional de Mineração 2024). A law was created in Minas Gerais (Law No. 23,291, of 25/02/2019, Sistema Integrado de Informação Ambiental 2019) that prevents the construction, installation, expansion, or raising of dams where there is a community in the so-called self-rescue zone: the portion of the valley downstream of the dam where there is no time to intervene in an emergency situation. However, these laws do not appear to be obeyed and dams may still be built if there is no alternative method.

The best way to replace the problematic tailings dams is dry mining (Davies and Rice 2001). Dry ore beneficiation is ideal because it allows the ore to be processed with very little or no water. In other words, the leftovers from the ore beneficiation are filtered and placed in large piles, replacing the use of traditional dams. Dry mining also makes it possible to generate a substrate that can be used in the production of new products, including sand for asphalt paving and bricks for civil construction. In addition, this substrate can be vegetated and, in this way, contribute to the recovery of nature (Davies and Rice 2001). However, this method of beneficiating the ore is much more expensive and, unfortunately, there are still several active tailings dams in Brazil, many of them upstream and in critical condition. It is important to emphasize that it is not enough to simply deactivate these dams, as the mud remains stored and the dam could break at any time. Heavy rains can generate floods that could rupture the reservoir. Unfortunately, a common practice among mining companies is to hire technicians to assess the condition of their dams and the risk of rupture. This is as incoherent as “putting a fox to guard a henhouse”. It is up to the government to inspect all of this and do an impartial and thorough assessment. Therefore, in addition to replacing the dams with a more modern and safer tailings processing system, it is essential that these dams be monitored and emptied to prevent overflows.

The mud spill is still affecting lives, health, economy, culture, and biodiversity. Over the years, the impact has increased in intensity, severity, and area, ranking as one of the major environmental disasters worldwide. In association with other threats such as climate change that induce extreme events such as cyclones and heavy rains, which foster pollutant resuspension, Fundão spills are even more worrisome to terrestrial and aquatic species in a wide range of globally important sites for conservation, as well as for human population that depend on these ecosystems.

The path to healing the Rio Doce requires a multi-pronged approach. Effective public policies are essential, encompassing compensation for affected communities, restoration initiatives, and long-term conservation programs. These policies, rooted in current scientific research, should prioritize rebuilding resilient ecosystems and river protections. Collaboration is paramount. Local and indigenous communities hold invaluable knowledge of the Rio Doce and fostering their inclusion provides a sense of ownership over its revival. Partnering with scientific experts ensures evidence-based restoration strategies and tracks their effectiveness. By implementing these solutions and supporting a collaborative conservation strategy, the long journey to heal the Rio Doce ecosystem and the lives it sustains can truly begin.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Cássio Cardoso Pereira, Geraldo Wilson Fernandes, and Fernando Figueiredo Goulart conceived the ideas; Cássio Cardoso Pereira and Fernando Figueiredo Goulart led the writing of the manuscript. Stephannie Fernandes made edits and also contributed to the main text. All authors contributed critically to the drafts and gave final approval for publication.

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Data availability

All of the data that support the findings of this study are available in the main text.

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