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Special Series

Understanding the Science Surrounding Environmental Consequences and Rehabilitation Actions Stemming from Brazil's Fundão Tailing Dam Rupture

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EDITOR'S NOTE:

This article introduces the special series "SETAC Fundão Dam Rupture Environmental Science Meeting" published in this issue of *Integrated Environmental Assessment and Management*. The SETAC Fundão Dam Rupture Environmental Science Meeting was held in Brasilia, Brazil (26–27 June 2019), focusing on the scientific aspects associated with environmental recovery of the Mariana-Rio Doce river basin.

ABSTRACT

Collapse of the Fundão tailings dam in November 2015 in Minas Gerais, Brazil, resulted in the release of approximately 36 million cubic meters of primarily clay and fine sand–sized particles to the environment. The spill event extended over 600 km of the Rio Doce catchment and affected terrestrial and aquatic ecosystems and compromised socioeconomic activities throughout the watershed. Numerous monitoring programs and research investigations in the catchment since that time contribute to better understanding of the environmental consequences and plans for rehabilitation of the landscape. The Society of Environmental Toxicology and Chemistry (SETAC) Latin America Geographic Unit hosted the Fundão Dam Rupture Science Meeting in Brasilia, Brazil, in June 2019 to report on the findings from these studies. Fourteen technical papers from that meeting are presented in this *Integrated Environmental Assessment and Management* (IEAM) special series. These papers and the technical discussions at the meeting reflect the consensus opinions of scientists who attended the symposium. Delegates generally agreed that society must commit to rehabilitation after disasters based on the best available evidence describing the structure and function of affected ecosystems. Scientists can play a crucial role in prioritizing and facilitating rehabilitation actions, as well as monitoring for progress toward achieving goals. *Integr Environ Assess Manag* 2020;16:569–571. © 2020 SETAC

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RESUMO

O colapso da barragem de rejeitos de Fundão em novembro de 2015 em Minas Gerais, Brasil, resultou na liberação de aproximadamente 36 milhões de metros cúbicos de partículas do tamanho de argila e areia fina para o meio ambiente. O derramamento se estendeu por mais de 600 km na bacia hidrográfica do Rio Doce, afetou os ecossistemas terrestres e aquáticos e comprometeu as atividades socioeconômicas em toda a bacia hidrográfica. Numerosos programas de monitoramento e pesquisas na bacia, desde então, contribuem para uma melhor compreensão das consequências ambientais e para os planos de reabilitação da paisagem. A Sociedade de Toxicologia e Química Ambiental (SETAC) da América Latina sediou o Encontro Científico sobre a Ruptura da Barragem do Fundão em Brasília, Brasil, em junho de 2019, para relatar os resultados desses estudos. Quatorze artigos técnicos dessa reunião são apresentados nesta série especial da revista *Integrated Environmental Assessment and Management* (IEAM). Esses artigos e as discussões técnicas do encontro refletem as opiniões consensuais dos cientistas que participaram do simpósio. Os delegados em geral concordaram que a sociedade deve se comprometer com a reabilitação após desastres com base na melhor evidência disponível que descreva a estrutura e a função dos ecossistemas afetados. Os cientistas podem desempenhar um papel crucial na priorização e facilitação de ações de reabilitação, bem como no acompanhamento da evolução do cumprimento das metas. *Integr Environ Assess Manag* 2020;16:569–571. © 2020 SETAC

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INTRODUCTION

The Fundão Dam Rupture Science Meeting held in Brasilia, Brazil, on 26 and 27 June 2019 was the first focused scientific meeting organized by the Latin America Geographic Unit of the Society of Environmental Toxicology and Chemistry (SLA). Despite widespread media and scientific interest, the meeting was the first dedicated strictly to an apolitical focus on the environmental science issues surrounding the November 2015 Fundão tailings dam accident in the Brazilian state of Minas Gerais. Over the course of the 2-day meeting, scientists shared 24 platform and 49 poster presentations discussing various terrestrial and aquatic aspects of the tailings dam accident. The technical knowledge exchange succeeded in providing a foundation for technical discussions concerning environmental rehabilitation of the nearly 600 km of the Rio Doce watershed affected by the release of approximately 36 million cubic meters of primarily clay and fine sand–sized material to the environment.

The environmental consequences and ongoing rehabilitation of one of the world's largest mine tailings dam ruptures continues to be the subject of scientific study in Brazil nearly 5 years after the incident. The accident itself and several scientific questions spurred by the significant environmental disruption are among the top 20 environmental topics of most concern to Brazilian environmental professionals, as revealed by SLA as part of its Global Horizon Scanning Project (Furley et al. 2018). Many of these same concerns were highlighted yet again in January 2019 following the rupture of a second tailings dam at the Córrego do Feijão mine located near the village of Brumadinho and also in the state of Minas Gerais, Brazil.

The 128 delegates from academia, business, and governmental organizations in Brazil were invited to submit papers for this special technical series in *Integrated Environmental Assessment and Management* (IEAM). The 14 papers published in this issue (https://setac.onlinelibrary.wiley.com/toc/15513793/2020/16/5) reflect the enormity of the complex ecological, scientific, and social issues generated from the tailings dam accident. The strong desire among delegates to disseminate findings from the meeting to the scientific community in Brazil inspired publication of both English and Portuguese language versions of the abstract for each of the papers in this series. As coleaders for the Fundão Dam Rupture Science Meeting and guest editors for this special series, it is our hope the dual-language abstracts enhance accessibility of the papers to the larger technical community located in Brazil and elsewhere around the world. We also hope this becomes a feature of other IEAM special issues dedicated to reporting on the scientific discourse of issues relevant to other global regions where English is not the primary spoken language.

The 14 papers published in this special series reflect the broad set of topics discussed at the Fundão Dam Rupture Science Meeting. Ecological topics focused on the concentrations of metals and metalloids in the tissues of fishes in the Rio Doce and tributaries of the river system, ecotoxicity testing results for receiving waters, acoustic surveys to assess fish biomass and habitats, the use of bees as bioindicators of terrestrial impacts, persisting ecological risks in the estuary, metals in soils and crop and pasture plants, terrestrial rehabilitation using native woody species, and methods for post-incident impact assessment of the terrestrial ecosystem. Fluvial geomorphology and/or hydrology topics focused on receiving river transport of clay to silt sized sediments, characterization of the sediments left in an impoundment with respect to their potential use in rehabilitation works, changes to riverine water quality, and measurement of incident-related sediment transport to the coast and associated changes to coastal water and sediment quality. Societal topics were only briefly discussed at the meeting and in this special series are represented by a review of changes to social movements and organizations after the tailings dam incident.

KEY THEMES FROM THE MEETING

Investigation of the Fundão dam rupture differs from impact assessment work typically conducted to evaluate disruptions caused by human actions or nature. Impact assessment work typically predicts the likely consequences and environmental changes induced by sudden changed conditions or an accident relative to the past. In contrast, studies of the Fundão dam rupture incident have little or no baseline information from which to determine or predict the likely magnitude and spatial scales of changes to the different terrestrial and aquatic ecosystems along the 600-km Rio Doce watershed. There had been little scientific study of the watershed, to date. Therefore, many of the conclusions drawn from environmental assessments have been made using conceptual models or extrapolations from similar habitats and ecosystems located elsewhere. Thus, although scientific study is acknowledged as valuable, scientists must work with affected communities to prioritize actions that improve environmental quality using best available information no matter how imperfect or incomplete, and as quickly as possible.

The consequences of the Fundão dam rupture incident, at times, were closely connected to both ecology and societal changes. Thus, it was evident that environmental assessments required the integration of several different nature and human perspectives, some of which were outside the comfort zone of scientists accustomed to working within a narrow discipline. Discussions at the meeting emphasized the need for collaboration networks, and indeed, meetings such as the Fundão Dam Rupture Science Meeting highlighted the importance of bringing different technical and socioeconomic disciplines together for the exchange of knowledge and to improve multidisciplinary integration. Some environmental impairments such as those to fisheries and agriculture lands in the upper reaches of the Rio Doce watershed require societal rehabilitation at a pace faster than the time frames typically associated with scientific studies and careful restoration planning and field trials supporting ecological rehabilitation. The restoration of village functions and the repair

of the livelihoods of community residents affected by sudden disruptions is of paramount importance.

And although innovative environmental assessment methods might bring faster, less destructive, and in some cases, more accurate measurements, innovative methods needed to be used in parallel with more traditional investigation methods to aid interpretation and validate some results. That said, the general lack of baseline ecological, geomorphological, and terrestrial data was a deficiency no matter what assessment methods were used in the field investigations reported at the meeting. This lack of comparative information highlighted the importance of establishing robust baseline data collection programs in remote areas at risk of industrial accidents now or at some time in the future.

This, in turn, means that reliance on national or international environmental guideline values cannot be sufficient for defining restoration work for an incident of the scale and complexity of the Fundão dam rupture. There should be a preference for derivation and application of locally relevant environmental goals for restoration purposes. And because rehabilitation activities themselves could create further environmental disturbances, locally relevant environmental restoration goals must also acknowledge that a return to predisruption conditions may not be possible in the short term and, in some cases, may never be realized. And although rehabilitation activities should strive to generate net benefits for affected ecosystems and communities, those benefits may be new or unfamiliar relative to the environmental conditions that existed prior to disruption.

Although acute toxicity was shown to have ceased, chronic ecotoxicity associated with rainy season increases in the suspended sediment loads, and removed by filtration, remained in the catchment. These findings led to calls to focus monitoring more on benthic species, but with continuance of monitoring of water quality and elemental concentrations in fish tissues. It was noted that the estuary and coastal areas were the ultimate sinks for the sediments from the incident.

It was readily acknowledged at the meeting that the consequences of the Fundão dam rupture incident to people and communities were not sufficiently discussed. Scientists studying the incident needed to be careful to avoid enhancing public concerns by making alarmist statements about possible health impacts on the basis of limited data sets. Future work on restoration of the Rio Doce watershed could benefit from carefully designed, integrative, multidisciplinary studies involving assessment of the human health impacts.

It was evident to delegates that the time had come for local leaders to continue to work toward rehabilitation on the basis of the best available technical evidence. Scientists in Brazil can play a crucial role in the future recovery of the region by providing sound, evidence-based insights into how best to facilitate rehabilitation of the Rio Doce watershed.

As a final comment, we, the guest editors, wish to thank all the participants of the meeting for their contributions to the discussions, the presenters for providing the backbone of the meeting content, the authors of the papers in this special series for helping others to understand the impacts of the incident, and the meeting organizing committee for making the event a reality.

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