Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2020-159-AC1, 2020

Natural Hazards and Earth System Sciences
Discussions
Open Access
EGU

Interactive comment on "Modelling the Brumadinho tailings dam failure, the subsequent loss of life and how it could have been reduced" *by* Darren Lumbroso et al.

Darren Lumbroso et al.

d.lumbroso@hrwallingford.com

Received and published: 7 September 2020

Comment: What is the pink colored boundary on the map?

Reply: This is the maximum extent of the mudflow. In the original legend of this figure an incorrect colour was used. This has now been rectified so that the colour in the legend reflects the colour on the map and the figure has been updated.

Comment: This is extremely high discharge. Would be helpful to present the fully formed breach geometry as well as the dam height, crest length and initial reservoir level prior to the breach initiation.

Printer-friendly version

Discussion paper

Reply: Tailings dams discharges tend to be very high. A study carried out on an unnamed tailings dams in the USA indicated that the peak discharge could be between 25,000 and 60,000 m3/s. (see Martin & Akkerman Challenges with conducting tailings dam breach assessments, ICOLD meeting, 2017). Other references quote estimated tailings dam discharges as high as 500,000 m3/s (see Milanović P.T. (2019) Dam engineering and its environmental aspects. in: LaMoreaux J. (eds) Environmental Geology. Encyclopaedia of Sustainability Science and Technology Series. Springer, New York, NY. https://doi.org/10.1007/978-1-4939-8787-0_308). The paper has been updated with these references to indicate to the reader that tailings dam discharges can be very high. With regards to the fully formed breach geometry the whole of the dam collapsed so the fully formed breach geometry is the same as the sides of the valley. The text in the paper has been updated to reflect this.

Comment: Mixed?

Reply: The text has been revised so it now reads “a mix of cases”

Comment: I am not sure that you could say that LSM is more transparent and more defensible as a general rule, when compared to RCEM (and DSO-99-06). For LSM, a lot depends on the assumptions made regarding the transportation model and warning/mobilization efforts and how well these assumptions are documented. Also, the accuracy of input data affects all modeling efforts and LSM is no exception.

Reply: This is correct and the paper has been revised to reflect this.

Comment: Each house was "assumed" to have two people.

Reply: Yes this is correct. The paper has been updated to make this clear.

Comment: You should mention that the LSM assumes a 100% fatality rate for persons located in collapsed buildings.

Reply: The paper has been updated to reflect this point.

Comment: You should definitely mention that once the "least cost path" is assigned to an individual, or group of individuals, it cannot be changed during the model simulation. Evacuees whose route is blocked by congestion, or flooded, cannot change course. In some situations, this can be interpreted as a limitation of the model, since in a real situation some people would change course when attempting to evacuate.

Reply: Text about the least cost path method has been added to the paper. However, evacuees whose routes are blocked can change course. The LSM is dynamic and so roads and paths which are flooded and become impassable, lead to a recalculation of the “least cost path”. People evacuating are then directed to the next closest safe location. The paper has been revised to clarify this point.

Comment: Need to discuss assumptions related to how the breach in progress would be identified, decisions by authorities leading up to the issuance of warning, how warning would be issued and spread through the community, would people be assumed to take the warning seriously and how long would they delay mobilization.

Reply: Rotta et al in paper published a paper in April 2020 entitled “The Brumadinho tailings dam collapse: Possible cause and impacts of the worst human and environmental disaster in Brazil”. Remote sensing data of the dam appears to indicate that the soil moisture content of the structure was increasing several months before the failure. The paper has been revised to indicate that satellite based data can potential be used with in-situ monitoring to detect possible danger signs in tailings dams months in advance. There could be a coloured coded level of risk assigned to the tailings dam related to long-term issues (e.g. red, amber, green) which could have been disseminated regularly to the people at risk both at the site and downstream.

One method to alert people at risk downstream of such structures is the use of a robust siren system. It is thought the system of sirens did not work during the Brumadinho dam failure itself. However, on the morning of 27 January, two days after the disaster, sirens were sounded because there were concerns regarding the stability of Dam VI,

a process water reservoir, adjacent to the structure which had failed, where increased water levels had been detected. Owing to the risk posed by this structure, approximately 24,000 residents downstream of the site were successfully evacuated (Vale, 2019).

There is a large body of evidence that sirens are an effective method of warning of possible dam failures provided that they are tested regularly; the test soundings are different from the emergency signal and that people know where to evacuate to when they hear them (Graham, 2008; Tudor et al., 2012). The paper has been revised to reflect these points.

References: Vale (2019) Vale updates information on the dam breach in Brumadinho 27 January 2019, see http://www.vale.com/EN/investors/information-market/Press-Releases/Pages/Vale-updates-information-on-the-dam-breach-in-Brumadinho.aspx
Housing and Land Rights Network (2019) Brazil: Another Mining Dam Disaster 28 January 2020 see http://www.hlrn.org/news.php?id=p21sYw==#.X037B8jdvcs
Graham, W.J. (2008) The Teton Dam failure - An effective warning and evacuation
Tudor, I., Bublić, I and Vukadin, V. (2012) The sound propagation prediction of the siren alarm system for Peruća hydropower dam, Euronoise conference, June 2012

Comment: It is fairly intuitive that increased warning time decreases the chance of fatalities. What else can you say about it? Are there insights gained from the modeling which provide a unique perspective? For example, it looks like there are lower numbers of fatalities from people evacuating in vehicles rather than just on foot. Most buildings in the flood zone collapsed, so there a wasn't a good change to shelter in place.

Reply: Yes this point is correct. People couldn't shelter in place because the structures couldn't withstand the force of the mud flow. We have carried out additional modelling to look at the sensitivity of the number of fatalities to the response time of people to the warnings both at the site and in villages downstream. The paper has been updated with these results which are also discussed.

Printer-friendly version

Discussion paper

Comment: How could there have been 15 minutes of advance warning for this type of failure? Would instrumentation at the dam, combined with an early warning system have been able to provide the advance warning?

Reply: It has been stated that the Brumadinho dam was instrumented. Whether additional in-situ instrumentation of the dam could have provided a 15 minute warning time is debatable. Rotta et al in paper entitled “The Brumadinho tailings dam collapse: Possible cause and impacts of the worst human and environmental disaster in Brazil” published in April 2020 found that: “A time series analysis of satellite-driven soil moisture index showed that the water accumulated over the Brumadinho dam surface during a protracted period increased its moisture contents and accelerated see-page erosion (piping) through the fill. We provide solid evidence of the seepage erosion from the top through the fill, which chronically weakened the structure and likely led to the collapse of the dam”. Remote sensing date could have potentially flagged up some issues with the structure several weeks or even months in advance of the failure. However, it is not clear if additional in-situ instrumentation could have helped to provide a 15 minute warning time. The paper has been revised to reflect these points.

The main reason for running the LSM with a 15 minute warning time was to find the warning time required in order for there to be no fatalities. The paper has been revised to reflect this and the other points mentioned above.

Comment: What are the characteristics of a "fantasy" document?

Reply: The characteristics of a “fantasy” emergency planning document are as follows: They make statements or promises which will never be fulfilled; They make claims that the event being planned for is understood and can be controlled; There is a failure to consider human factors, for example how age, gender, culture, disability and socio-economic status affect people’s response to different emergencies; The risks are not fully or sufficiently well assessed and described; The coherence of the organisational coordination and the simplicity of society are often overstated; The plan describes a

rational sequence of events during a disaster which is not necessarily the case

These points have been added to the revised text.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2020-159, 2020.

Printer-friendly version

Discussion paper