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Reasons for investigating the organizational dynamics of the Vale tailings dam disaster in Brumadinho, Minas Gerais State, Brazil

Razões para investigar a dimensão organizacional nas origens da catástrofe industrial da Vale em Brumadinho, Minas Gerais, Brasil

Razones para investigar la dinámica organizativa del desastre de la presa de relaves de Vale en Brumadinho, Minas Gerais, Brasil

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The collapse of the iron ore tailings dam operated by the Vale mining company on the Córrego do Feijão stream in Brumadinho, Minas Gerais State, Brazil, was a large-scale work accident, the largest in Brazil's history [1]. The dam failure occurred just over three years after the disaster with the Fundão tailings dam operated by the Samarco company in Mariana, Minas Gerais State, which until Brumadinho was considered "*one of the country's worst socioenvironmental disasters*" [2] (p. 6).

The Brumadinho disaster caused more than 300 fatalities (counting the victims already identified and those still disappeared) and immeasurable impacts on the area's historical and cultural heritage, the environment, and the local economy [1].

Three days after the dam collapsed, when the media was focusing on the search for survivors, an attorney connected to the company gave a press interview stating the following [3]: "*Under no circumstances will the board of directors give up the company's reins*". "*Vale sees no determining reasons for its own liability. There was no negligence, recklessness, or malpractice*" [on the company's part] [3].

Although Vale representatives disallowed the attorney's remarks the same day [4], the attorney revealed not only his own insensivity by defending other priorities, like the financial health of the company and the current board members' positions, but also went out of its way to influence the inquiry into the disaster's causes and their explanation, a key strategy used by corporations to repair their image in times of crisis [5]: "*Why does a dam break? There are numerous factors, which will now be the object of considerations of a technical order*" [3].

In the Samarco case, an independent investigation was hired by the mining consortium to determine the technical factors that caused the dam to collapse, overlooking the socio-organizational factors associated with the dam's failure, which are fundamental for establishing preventive measures [6].

Thus, if "*Mariana was a tragedy waiting to happen*" [2] (p. 2), what about Brumadinho?

The aim of this article is to emphasize the need for a more consistent approach to the investigation of industrial disasters in general and specifically the Brumadinho dam failure.

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Analysis of industrial disasters in the age of globalization

From a systemic perspective, the investigation of disasters should reveal aspects of the history of the system's operation shortly before the disaster happened, including latent or incubated factors, with studies on the immediate and late consequences, the latter requiring active search strategies.

Studies of manmade disasters in the last 40 years have shown that they are phenomena with technical dimensions originating in decision-making processes in complex situations that involve processes that act jointly, exposed to numerous simultaneous influences [7].

Analyses that are limited to technical explanations are unable to elucidate how the shortage of resources, conflicting corporate targets, and decisions made in the face of social, cultural, and political changes influence the event. Thus, in modern methods, the technological aspects are considered starting points; after all, they do not result from spontaneous generation. The explanations should not focus only on the search for problems in the functioning or flaws in single parts or components in the social and technical system under investigation [7].

An in-depth analysis by Vaughan [8] of the accident with the *Challenger* space launch has been considered a methodological milestone, because it unveiled interactions between technological, human, and organizational factors in order to understand what went wrong with the rocket launch.

The experience with analyses that propose to explore the organizational dimensions and their multiple interactions shows that every accident involves complex social processes, full of disputes, political resistances, and/or spaces for freedom, dialogue, and cooperation [7,8].

Companies like Vale are part of a global process of competition, characterized by the opening of world markets to capital flows via trade deregulation and liberalization, attempting to attract international investments for new projects [9]. Their operation, which entails major technological risks pressured by the corporate shares' appreciation/depreciation on the stock markets, depends on strategic choices in the use of technologies, management, and organization, potentially increasing their complexity and affecting the performance and safety of their multiple units [2,9,10].

In the globalized scenario, understanding the technological dimensions is not sufficient to explain industrial disasters. Administrative, organizational, and strategic choices can place technological and operational processes in jeopardy, as Le Coze [9] described in the British Petroleum (BP) accidents from 2005 to 2010. In the case of BP, the inquiries identified a management approach focused on financial profitability and cutbacks in operational costs, increased outsourcing and reduction in the company's own workforce, decreased state regulation, and bureaucratization of safety services.

When an accident happens that interrupts the production cycle in these companies or their production units, it should be analyzed on the basis of internal dynamics and their development and place in the industry and production site and in the regulatory and oversight context [9].

The history of major industrial disasters shows that active engagement in understanding what has happened provides an opportunity for an organizational learning process, not only for the companies involved, but also for the oversight and licensing agencies (among others). Relevant strides in legislation and regulation, the regulatory agencies' role, and prevention and safety practices and methods have resulted from the in-depth investigation of disasters [1].

Moving beyond the technical explanation or staying with Mariana?

Brazil has suffered numerous obstacles to the development of in-depth organizational analyses of disasters. Inquiries have typically focused on mistakes by engineers in the projects, in operations, or in report submissions, since the search has traditionally been for mistakes by machinery operators, a mechanism used to exempt board members and government authorities from their responsibility [12].

To explain disasters caused by mining companies from a strictly technical angle (geotechnical in these cases) pertaining to the dam's situation prior to the collapse does not allow reaching the political and organizational factors at the root of the decisions underlying the dam's technical problems, thus making only a limited contribution to the prevention of subsequent accidents [6,7].

At the time of the Samarco disaster in Mariana, the mining industry was suffering a serious downturn, involving an aggressive stance by the company, with an emphasis on increasing the production

scale with ore and tailings in order to withstand the financial pressures and guarantee the shareholders' profits. Tailings dam collapses are known to be associated with periods of downturn [10].

Action by the federal and state oversight agencies was also precarious. The mining companies themselves influenced the nominations to the executive positions in the regulatory agencies, in a context that prioritized Brazil's export commodities policy [1,2,10].

These issues justify investigating the management and organizational dynamics in order to determine their relations with problems in the Fundão dam's use, maintenance, safety, and design.

However, focusing only on the technical investigation and avoiding an in-depth organizational analysis of the disaster was apparently the strategy adopted by Samarco in Mariana. This also applies to the recent Brumadinho disaster, as illustrated by the attorney's remarks quoted above.

In search of the organizational origins of the Vale disaster in Brumadinho

Two aspects far removed from the dam's actual collapse require considering the company's management strategies when investigating the accident.

From 2014 to 2017 (which includes the year of the disaster in Mariana), Vale pursued an aggressive strategy of maximizing shareholders' returns while reducing the company's annual investment in operations maintenance, from USD 4 billion in 2014 to USD 2.2 billion in 2017. Disaggregated data show that the expenditures in "tailings piles and dams" and "health and safety" were reduced during this period from USD 474 million to USD 202 million and from USD 359 million to USD 207 million, respectively. Importantly, this strategy was adopted during a time of iron ore market growth [13].

Another strategy pursued by Vale has been to lobby the legislation that regulates mining and its environmental and social impacts, besides influencing the functioning of public oversight and inspection agencies, especially via handpicking company-supported persons for executive positions in these agencies [1,2,10,14]. The environmental legislation prevailing in the state of Minas Gerais since December 2017 was secretly influenced by Vale employees. The legislation simplified the environmental licensing process, decreased its stages, and was applied in the case of the Córrego do Feijão mine in Brumadinho [15].

This was the scenario for the worst work disaster in Brazil's history, which in itself demonstrates the need for an investigation that adopts the socio-technical perspective [8,9] in its analysis.

The following questions can help orient an in-depth investigation.

The analysis should begin with the events and factors (human, technological, and organizational) at play before the dam's collapse. Elucidating the role of these aspects requires including all the dam's inhouse and outsourced employees, especially those in operations, maintenance, and safety, and those who dealt with the recommendations resulting from the dam's stability studies and recommendations by the regulatory agencies. Who did what and how? How were the recommendations processed? How does one explain the delays in acting on the recommended corrections? How did the budget cutbacks impact the dam's operation and maintenance?

The analysis should explain who knew about the problems with the dam and how they decided that the dam met the stability and safety requirements and could continue to operate under such conditions. It is also necessary to determine which injunctions weighed on these managers, since to keep the dam operating with such problems meant accepting less safety, taking deviations for granted, and creating the conditions for a sudden collapse.

Next, it is necessary to explore the latent or incubated conditions to elucidate decisions related to the dam's history associated with the blueprints, operation, and maintenance of its ten upstream heightening operations, monitoring the stability, and the emergency plans that failed. It is necessary to explain: the implementation of a dam failure alarm system without redundancy that was "engulfed by the mud" and failed to function; and the construction of administrative buildings and a dining hall downstream from the dam, even after the Samarco disaster three years earlier that had destroyed the township of Bento Rodrigues located kilometers downstream from the dam in Mariana.

In times of financialization, even the Samarco tragedy failed to lead to a revision in management practices. An organizational analysis of the case means exploring how the decision-making processes occur in the hierarchical chain in Vale. Who participates? Are there pressures to prioritize sharehold-

ers' interests? How are they expressed? Are there disputes for results between the company's units? Do they include payment of bonuses to managers based on higher performance indicators? Was there any debate on reducing investments in the dam's safety and operations? Who defended the cutbacks, and based on what arguments? In defense of prevention, the analysis needs to make the company face up to its decisions and their implications.

Likewise, an in-depth investigation should analyze the interventions by government agents in licensing, oversight, and inspection of the mine's operations at Córrego do Feijão and interactions with the company's employees. What was the margin of action for the agents at various hierarchical levels and from government? What obstacles were there to their action? Were such obstacles political, technical, organizational, or related to qualifications? Did the current licensing modality have any impact? Were technological alternatives to the dam's use considered during the licensing process?

Our discussion here is not intended to exhaust the issues to be investigated, but to illustrate the avenues for a socio-technical analysis of the Brumadinho disaster.

Final remarks

Vale and government officials should take their responsibility and guarantee the process of organizational learning based on an in-depth and independent investigation in order to prevent similar disasters in the future

According to Llory & Montmayeul [7], to analyze an event of this magnitude by focusing merely on the proximal causes means to look for the explanation only in "the area under the light post", that is, a search limited to the more visible aspects, taking shortcuts in the process. Such an endeavor is both insufficient and biased, failing to explain the more obscure aspects that determine the occurrence of the proximal factors and the event itself.

Contributors

I. M. Almeida, J. M. Jackson Filho and R. A. G. Vilela participated in writing the article and approval of the final version for publication.

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