Dam Failure: Behavior and Trends in Brazilian Academia from The Perspective of The Mariana and Brumadinho Cases

Rompimento de Barragens: Comportamento e Tendência na Academia do Brasil sob a Perspectiva dos Casos de Mariana e Brumadinho

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ABSTRACT | Objective: This study examines the evolution, patterns, and trends of Brazilian scientific production on dam failures, emphasizing how academia has engaged with the Mariana and Brumadinho cases. **Methods:** A bibliometric and sociometric analysis was conducted on 52 peer-reviewed articles indexed in the SPELL database. The study mapped journals, institutions, and authors, and applied network analysis to assess collaboration structures and thematic centrality. **Results:** Findings reveal concentration of publications in a small group of journals (*Farol*, *RCCC*, *RCO*, *RMC*) and institutions (notably UFOP, UFJF, FGV-SP, UFRJ, UFLA, USP, and UFSC). Collaboration networks exhibit low density and high fragmentation, indicating fragile scientific integration. Core authors (e.g., Jussara Jéssica Pereira) and keywords (*Samarco*, *corporate crime*, *legitimacy*, *sustainability reports*) define the thematic agenda. The trajectory suggests a peak of interest after the Brumadinho disaster (2019–2022), followed by signs of decline. **Conclusion:** Despite the salience of Mariana and Brumadinho in shaping the academic agenda, Brazilian research on dam failures remains dispersed and underdeveloped in collaborative terms. This study provides a state-of-the-art overview, highlighting critical gaps and pointing to the need for stronger interdisciplinary integration, expanded use of international databases, and engagement with legal, social, and governance perspectives to advance knowledge on socio-environmental disasters.

Keywords | Mariana; Brumadinho; Dam failures; Scientific production; Sociobibliometrics.

RESUMO | Objetivo: Investigar o comportamento e a tendência da produção científica do tema rompimento de barragens na literatura acadêmica brasileira sob a perspectiva dos casos de Mariana e Brumadinho. **Método:** Foi um estudo com abordagem quantitativa, descritivo, exploratório, documental, embasado pelas técnicas de investigação da bibliometria e da sociometria em 52 artigos identificados na biblioteca eletrônica da SPELL. **Resultados:** Farol, RCCC, RCO e RMC foram as revistas científicas mais produtivas; UFOP foi a instituição mais profícua; Jussara Jéssica Pereira foi a pesquisadora mais central; UFJF, FGV (SP), UFRJ, UFLA, USP, UFOP e UFSC foram as instituições mais centrais; Samarco, crime corporativo, Brumadinho, mineração, responsabilidade social corporativa, desastre, relatórios de sustentabilidade, Mariana, desastres ambientais, rompimento da barragem, legitimidade, estudo de eventos, desastres, reputação, Teoria da legitimidade, Vale, crimes corporativos e barragem foram as palavras-chave mais centrais. **Conclusão:** Evidencia-se uma investigação em estado da arte do comportamento e da tendência da produção científica do tema rompimento de barragens na literatura acadêmica brasileira sob a perspectiva dos casos de Mariana e Brumadinho à luz da sociobibliometria, contribuindo assim para o desenvolvimento e maturação do tema rompimentos de barragens na academia do Brasil.

Palavras-chave | Mariana; Brumadinho; Produção científica; Periódicos brasileiros; Sociobibliometria.

1 INTRODUCTION

Nature establishes a harmonious bond with all living beings on the planet, and this balance is often disrupted by natural events or by human actions—either by initiative, when humans create or transform the natural essence of the environment, or by omission, when they fail to recognize the responsibility to defend or prevent harmful acts against life. Environmental disasters are consequences of these events, resulting in impacts on living beings and, simultaneously, on humans, as well as on social and economic spheres (Costa, Silva, Martins & Barbosa, 2023). In this regard, an environmental disaster can be defined, according to Article 2, item II of Decree 7.257/2010, as the result of hostile events, whether natural or human induced, upon a fragile ecosystem, causing damage to humans, material losses, or environmental harm, and consequently influencing economic and social setbacks (Brasil, 2010).

In Brazil, the years 2015 and 2019 were marked by major environmental disasters in the country, these were: the collapse of the Fundão dam in the municipality of Mariana (MG), operated by Samarco Mineração S.A. (controlled by Vale S.A. and BHP Billiton), which occurred on November 5, 2015, causing a massive wave of mud that led to the death of 19 people, thus becoming the largest environmental disaster in Brazil; and the collapse of the Córrego do Feijão mine dam in the city of Brumadinho (MG), which occurred on January 25, 2019, with Vale S.A. as the responsible company, claiming the lives of 270 people (Fabrício, Ferreira & Borba, 2021; Bandeira, Sousa & Santos, 2022; Macedo, Abrantes, Valadares & Miranda, 2023).

In general, these environmental disasters brought numerous financial and socio-environmental problems to the affected regions and, overall, intensified discussions on control and oversight policies, as well as on the negative externalities of mining activities for the municipalities of operation and neighboring areas, as well as for the regions and States of the Brazilian Federation (Fabrício, Ferreira & Borba, 2021; Bandeira, Sousa & Santos, 2022; Macedo et al., 2023).

Regarding the economic/financial focus, the results show that both environmental accidents negatively impacted the shares of Vale S.A. in the Brazilian corporate and capital markets. More specifically, in the case of the Mariana disaster, it was observed that the stock price of Vale S.A. dropped by 13.55% within a week, characterizing a weekly moving average of -2.30%, which also influenced the Bovespa Index (Ibovespa), which fell during the same period. In the case of Brumadinho, however, the drop in stock prices occurred more unexpectedly, reaching 24.52% on the first business day after the disaster, in addition to a weekly

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moving average of -2.88%. Nonetheless, it did not have as significant an impact on the Ibovespa index, thus differing from the Mariana case (Fogaça, Raeder & Marques, 2023).

With regard to environmental *disclosure*, it was found that in both cases Vale S.A. reported relevant facts and dedicated exclusive explanatory notes to the catastrophes in the quarterly financial statements of the period of the incidents, in order to provide greater detail to *stakeholders* (Fogaça, Raeder & Marques, 2023). Concerning Samarco S.A., it was verified that the environmental disaster severely impacted the company's environmental *disclosure*, altering standards in the sustainability report based on deterrence strategies aimed at both eliminating and, at the same time, repairing the objective reality (Amorim & Souza, 2022).

Thus, Samarco S.A. resorted to a defensive stance through which it sought to exempt itself from responsibility by manipulating negative environmental *disclosure*, aiming to divert *stakeholders* attention from adverse information (Amorim & Souza, 2022). In summary, the reporting of socio-environmental actions through sustainability reports enhances environmental *disclosure*, strengthens organizational legitimacy, and, consequently, improves the company's reputation within the corporate market (Alves, Carneiro & Paiva, 2020).

Succinctly, tailings dams represent a critical aspect of mining sector infrastructure, as they play a vital role in waste management. Nevertheless, the failure of such dams can result in catastrophic consequences for both the environment and society, particularly for human communities. The collapses of the Brumadinho and Mariana dams serve as dramatic examples of these failures, leading to significant socio-environmental devastation and profound economic losses in the regions affected by these environmental disasters in Brazil (Rodrigues Junior, Oliveira, Souza, Almeida, Viana, Ponciano & Silva, 2023). Accordingly, it is evident that dam failures have become a subject of increasing academic attention, particularly in light of the Mariana and Brumadinho cases (Sousa, Santos de Araújo & Barbosa, 2021).

That said, it is emphasized that scientific production is a collaborative social endeavor in which scientific knowledge is the outcome of a cumulative process derived from the cooperation among actors involved in the construction of academic research on themes that are published, disseminated, and socialized within academia. This premise positions sociobibliometrics—that is, the integration of bibliometrics and sociometrics, also known as Social Network Analysis (SNA)—as an essential and necessary set of investigative techniques for examining the production of academic research on key topics, such approaches facilitate theoretical development by identifying *gaps* and opportunities for future studies. Concisely, sociobibliometrics serves the function of thoroughly exploring scientific output on a given subject, highlighting the characteristics of the social networks formed by the actors who have contributed to the investigated theme (Ferreira & Silva, 2019; Costa, Knop & Felippe, 2021; Ribeiro & Corrêa, 2022).

Therefore, it is emphasized that efforts are required to strengthen cooperation in the study of tailings dam failure disasters, in order to further advance scientific research on environmental disasters, particularly with regard to dam ruptures (Wu, Ye, Hu, Wang & Tan, 2023). In this context, the present study is guided by the following research question: What is the behavior and trend of scientific production on the theme of dam failures in Brazilian academic literature, considering the cases of Mariana and Brumadinho?

Thus, the objective becomes evident: to investigate the behavior and trend of scientific production on the theme of dam failures in Brazilian academic literature from the perspective of the Mariana and Brumadinho cases. The justification for investigating Brazilian scientific production on this topic, particularly regarding the cases of Mariana and Brumadinho, lies in the fact that these are considered the largest environmental disasters to have occurred in Brazil (to date) in the years 2015 and 2019, which resulted in hundreds of deaths, thousands of displaced people, and severe environmental contamination (Bandeira, Sousa & Santos, 2022; Mazzari, 2023).

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To investigate the scientific production on the aforementioned topic, the *Scientific Periodicals Electronic Library* (SPELL) was chosen, as it is a Brazilian database platform that focuses on national scientific journals. It has broad coverage in the fields of Administration, Accounting, and Tourism, and is therefore considered one of the main Brazilian databases (Oliveira & Lavarda, 2023). It is emphasized that SPELL, to date, accounts for more than 68,000 documents, 43 million accesses, and 15 million *downloads*, and records 120 journals (Anpad, 2024).

It is also highlighted that the prominence and relevance of SPELL lies in promoting fairer conditions for Brazilian journals, leading to less inequality, since all academic journals have the same visibility space and can be accessed primarily based on their content rather than the journal's *status*. Thus, SPELL's search mechanism is efficient, as it encompasses the scientific production of studies in the fields of Administration, Accounting, and Tourism within a single environment, aiming to facilitate researchers' search for articles on various topics (Rossoni & Rosa, 2024). Consequently, SPELL is one of the most widely used databases by scholars conducting sociobibliometric-focused research in Brazil (Ribeiro & Corrêa, 2022).

In consideration of this, the relevance of this research lies in its originality, since, up to this point, no study analogous to the present one has been located in the global academic literature regarding its problem and research purpose. The outcomes of this scientific work also align with presenting the state of the art on the topic of tailings dam failures from the perspective of the Mariana and Brumadinho cases, contributing to academia by generating a better understanding and, simultaneously, comprehension of how the actors (authors and institutions) responsible for creating scientific value on this subject behave within the national literature, consequently, this enables the observation of the construction of academic knowledge through their collaboration networks, while simultaneously allowing the verification of trends in articles addressing the issue of dam failures from Mariana to Brumadinho.

2 TAILINGS DAM FAILURES: FROM MARIANA TO BRUMADINHO

Tailings dams are built throughout mining operations to contain the waste materials, which consist of residual byproducts left after the main material has been extracted from the ore. In other words, tailings are usually composed of sand, sludge, and clay particles suspended in a water-based slurry. It is also noteworthy that these tailings may contain chemical products used in the ore extraction process, which makes dam failures particularly concerning. Thus, mining dam failures have critical consequences for both ecosystems and human health, and their chronic contamination effects on biological material may be long-lasting, inevitably resulting in socio-environmental and economic damages for the affected regions (Rocha & Vasconcelos, 2023).

In recent decades, the impacts of mining activity worldwide have raised new questions in both political and academic spheres, a concern that has been exacerbated by recent events involving the failure of mining tailings dams in various countries, including Brazil. Among these cases, the most notable in terms of the impacts generated are the failures of the dams in Los Frailes Aznalcóllar, Spain, 1998; Ajka Alumina Plant, Kolontár, Hungary, 2010; Mount Polley, Canada, 2014; Jagersfontein, South Africa, 2022; and Williamson, Tanzania, 2022; as well as those that occurred in Brazil, namely the Fundão and Brumadinho dams. These mining tailings storage dam failures have caused significant social, environmental, and economic effects, in addition to damaging the reputation and credibility of mining companies due to the loss of human lives and the severe environmental harm they produced (Reis, Moura, Cota & Magalhães Junior, 2020; Cacciuttolo, Guzmán, Catriñir & Atencio, 2024).

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It is worth adding that, in addition to the environmental disasters of Mariana and Brumadinho, other dam failures also occurred in the state of Minas Gerais, these include: in 2001, the Macacos dam in the city of Nova Lima, resulting in 5 deaths; in 2003, the Cataguases dam, in the municipality of Cataguases, which caused contamination of the Paraíba do Sul River, the death of animals and fish, and the interruption of water supply for 600,000 people; in 2007, the Rio Pomba dam, in the municipality of Miraí, which left more than 400 people homeless or displaced; and in 2014, the Herculano dam, in the city of Itabirito, which resulted in 3 deaths. Therefore, it is emphasized that the safety of a dam must be the outcome of a combination of factors, including structural, geotechnical, hydraulic, operational, and environmental aspects (Pacheco, Henriques & Ribeiro, 2020).

At the end of 2015, the collapse of a tailings dam occurred in the city of Mariana (MG), resulting in the displacement of 600 families, 19 deaths, and the degradation of 1.469 hectares of vegetation, the disaster released more than 50 million cubic meters of tailings mud, which destroyed the districts of Bento Rodrigues and Paracatu de Baixo, both located in Mariana. This environmental devastation also affected other cities along the Doce River basin, spanning the states of Minas Gerais and Espírito Santo, severely disrupting the ecosystem of the regions and the lives of the survivors. Following the collapse of the aforementioned dam, the company Samarco had its operations in Mariana suspended, was fined, carried out mass layoffs, and signed a Conduct Adjustment and Transaction Term (TTAC) with its shareholders, the government, and regulatory and supervisory bodies, this agreement established strategies for reparation, assistance, and compensation for the individuals affected by this corporate crime (Alves, Carneiro & Paiva, 2020; Cadorin & Theiss, 2022).

In early 2019, Dam 1 of the Córrego do Feijão Mine, owned by the mining company Vale S.A., located in the city of Brumadinho, in the metropolitan region of Minas Gerais, collapsed and released approximately 13 million cubic meters of mining tailings into the environment. This environmental disaster is considered, up to this point, the largest occupational accident ever recorded in Brazil, as it resulted in more than 250 deaths, as well as in the destruction of the fauna and flora of the areas impacted by the collapse of the aforementioned dam in Brumadinho, which contained part of the Atlantic Forest biome. Consequently, the company Vale S.A. was fined by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) in the amount of R$ 250 million, and the organization also faced judicial actions leading to the freezing of its assets (Fogaça, Raeder & Marques, 2023).

Thus, environmental incidents such as those of Mariana and Brumadinho had consequences for society, one of which was the way in which the corporate market reacted. In this regard, the findings of Fogaça, Raeder, and Marques (2023) show that, in both the Mariana disaster and the Brumadinho accident, Vale S.A.'s shares were negatively affected, experiencing short term declines in their quotations, but eventually recovering in the long term. When comparing the two outcomes, the authors observed that the Brumadinho accident led to a sharper drop in share prices; however, the Ibovespa index did not follow this decline as it did in the Mariana case (Fogaça, Raeder & Marques, 2023).

In this situation, it is evidenced that the importance of the fact follows the intensity of the reactions verified in the capital market, in other terms, the more serious negative environmental news tends to be more prominent to the shareholders, insofar as there is the chance of the infringing company receiving fines and punishments that would echo, in the short term, in the company's cash flow. Thus, it is emphasized that the construction of the image and the reputation of a company is a slow, gradual process and subject to multiple events (Barbosa & Barros, 2021).

Thus, for the corporate market to evaluate the viability of an organization from a socio-environmental perspective, it is necessary that this company presents and points out initiatives that are effectively

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responsible. And, when this does not happen, the corporation shows itself to be even more susceptible to the negative reactions of the *stakeholders*, among them the investors, since the understood risk becomes high and the impact that will be observed in the pricing of the assets in case of an environmental disaster (Barbosa & Barros, 2021).

In this context, the research conducted by Barbosa and Barros (2021) is emphasized, as they examined the behavior of Vale S.A. shareholders in response to the accidents involving the collapses of the Mariana and Brumadinho tailings dams. The aforementioned authors found that, in the case of Brumadinho, the immediate divestment movement by investors was greater. One of the assumptions is that the three-day interval without trading until the first session after the accident provided the corporate market with more time to process the information. It is also highlighted that the fact that Brumadinho's operations were entirely controlled by Vale S.A., in addition to being a second instance of negligence regarding an environmental disaster, may have contributed to this outcome (Barbosa & Barros, 2021).

In summary, mining dam collapses have increased worldwide, with two major failures occurring recently in Mariana and Brumadinho, both in the state of Minas Gerais, Brazil. That said, research findings suggest that there were significant differences in post-disaster legal decisions between the cases of Mariana and Brumadinho. In Mariana, post-disaster management was privatized through the creation of the Renova Foundation. In Brumadinho, recovery and compensation measures were implemented more quickly, affected parties were recognized more promptly, and community participation was stronger from the very first hearings (Primo, Antunes, Arias, Oliveira & Siqueira, 2021).

However, accelerating individual settlement agreements, reducing the delay time for compensating losses and damages, and including community representatives in discussions and decisions did not substantially alter the usual procedures of mining production and waste storage, nor did they provide adequate resources to the populations affected by these environmental disasters. Finally, it was found that, although there were particularities in post-disaster management, the ultimate goal of the corporations responsible for the disasters was to protect their profits. Therefore, it is paramount to increase the understanding of dam collapses, particularly with regard to Mariana and Brumadinho, thus influencing the comprehension of this issue and contributing to the advancement of scientific knowledge in academia through future studies (Primo et *al.*, 2021).

3 METHODOLOGICAL PROCEDURES

The objective of this research was to investigate the behavior and trend of the scientific production on the theme of dam failures in Brazilian academic literature, under the perspective of the Mariana and Brumadinho cases. That said, in order to achieve this purpose, this study was: quantitative, descriptive, exploratory, documental, grounded and guided by bibliometric and sociometric research techniques (Pereira, Limberger & Anjos, 2021).

It is reiterated that bibliometric and sociometric procedures are used in review and quantitative research (Ribeiro, 2017), and are therefore essential to improve the context, enhance the discussion and the content of the articles investigated, while also contributing to the construction of social networks and the visibility of study groups of the actors responsible for generating knowledge on a given academic theme (Ferreira & Silva, 2019). It is further emphasized that studies employing methods that use bibliometrics and SNA or sociometrics give rise to the concept of sociobibliometric maps, thus highlighting the complementarity of these two techniques (Machado Junior, Souza & Parisotto, 2014).

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In summary, SNA makes it possible to identify scientific *clusters* of researchers who influence the informational and knowledge flow within the network, suggesting new interactions and partnerships to improve research and foster the development of scientific communication (Silva & Araujo Soares, 2021). Additionally, it is noted that in SNA, connections are visualized through correspondence analysis techniques by means of the elaboration and creation of matrices (Gomes & Silva, 2022).

Bibliometrics, as a research field within Information Science, plays a key role in investigating scientific production (Resende, Demo & Nascimento, 2019). Thus, in the effort to quantify articles related to scientific production, it is essential to mention the Laws that support bibliometrics, which are: *Lotka, Bradford, Zipf,* and *Price.* The Inverse Square Law, or *Lotka's* Law, refers to measuring the productivity of authors of scientific texts. According to this law, within a scientific specialty, there is a small number of highly productive authors alongside a large number of less productive academics. *Bradford's* Law, in turn, deals with the dispersion of researchers across different journal publications—in other words, this law measures and determines the core journals that most concentrate on publishing about a given academic subject. As for *Zipf's* Law, or the Law of Least Effort, it refers to the frequency of word occurrence in a long text and its significance to the subject under investigation. Finally, *Price's* Law, or the Law of Elitism, calculates the size of the elite group within a population of researchers working on a defined academic subject (Santos & Kobashi, 2009; Souza & Ribeiro, 2013; Machado Junior, Souza, Parisotto & Palmisano, 2016b; Pinheiro & Almeida, 2020; Hayashi, 2023).

Regarding SNA, its structure is constituted by the relationships among actors, with its formation being characterized and determined by the operationalization of the network's structural elements, which are: nodes, known as the actors; ties, which are the connections between actors; structural cohesion, which is the degree of concentration of actors; *small worlds*, which refer to areas of the network where the level of clustering among actors is high; the giant component, which is usually associated with the largest informational and knowledge flow within a given social network; and structural holes, which are inherent to the concept of small worlds (Machado Junior, Souza, Bazanini & Silva, 2016a; Ribeiro, 2020; Köhler, Digiampietri & Almeida, 2019; Köhler & Digiampietri, 2021).

Centrality identifies the most relevant actors in a social network, with the principle that the more central an actor is within the collaboration network, the greater its importance. It is noted that, for this research, (*degree*) centrality was used, which refers to the number of partnerships an actor has with other actors in a social network, and (*betweenness*) centrality, which measures the actors that control interactions in a social network, this means that these actors are responsible for mediating the flow of information and knowledge within the cooperation network. It is emphasized that degree and betweenness centralities were applied in this study, as they are the most frequently used in research focused on SNA (Machado Junior et *al.*, 2016a; Favaretto & Francisco, 2017; Grácio, 2018; David, Rodríguez, Siena & Paes-de-Souza, 2022; Ribeiro, 2023a).

Density demonstrates that the greater the number of reciprocal ties within a social network, the more information and knowledge will be shared among actors. It is further emphasized that density indicates that the denser the network, the closer its measurement will be to 1,0 (Farias Filho, Williams dos Santos & Conde, 2016), resulting in more uniform contacts among actors. Therefore, a network with low density, measured at 0,2, indicates a dispersed network with low internal cohesion (Williams dos Santos & Farias Filho, 2016). It is noteworthy that, for this research, greater emphasis was proactively placed on the measures of centrality and density (Urbizagástegui-Alvarado, 2022).

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3.1 Data Collection and Analysis Procedures

The SPELL database was selected for the search of studies on the research topic within Brazilian academic literature, the preference for SPELL is reiterated due to the fact that it is a Brazilian database platform focused on national journals, many of which originate from *Stricto Sensu* Graduate Programs linked to the National Association of Graduate Studies and Research in Administration (ANPAD), the institution that created this electronic data library (Costa & Domingues, 2023; Ribeiro, 2023b).

Thus, SPELL has extensive coverage in the fields of Administration, Accounting, and Tourism, which has led it to be recognized and legitimized as one of the main Brazilian databases in these areas of knowledge. It is also emphasized that, for review studies, SPELL is among the most widely used databases by researchers focused on this type of study within the Brazilian academic context (Costa & Domingues, 2023; Ribeiro, 2023b).

The search for studies on the central theme of this research in the SPELL database was first carried out through the selection of the following keywords: "Mariana," "Brumadinho," "Vale S.A.," and "Samarco." The use of these keywords is justified by their alignment with the scope and focus of this study (Alves, Carneiro & Paiva, 2020; Costa, Knop & Felippe, 2021; Gomes & Mayrink, 2022; Macedo et al., 2023). It should be noted that each of these keywords was used asynchronously in the SPELL "*drop down boxes*" search filter, within the fields: Document Title, Abstract, and Keyword.

In view of this, all academic works on the subject under analysis were identified and added to this research. It is emphasized that, in order to verify whether the selected article on the core theme of this study was truly compatible with its focus, the abstracts of the chosen articles were read, thereby ensuring that the selected scientific work adhered to the scope and focus of this investigation.

Therefore, the sample of this research comprised 52 articles consistent with the objective of this study, within a time frame of eight years, that is, from 2017 to 2024. It is noted that the first article identified on the main theme of this research in the SPELL database was published in 2017, while the most recent study was found in 2024. Subsequently, on May 26, 2024, the tabulation of the academic works began, and, simultaneously, the creation of the bibliometric indicators of this research was carried out, namely: periods, journals, authors, higher education institutions (HEIs), and word cloud, concluding their assessment on May 29, 2024.

With regard to SNA, the creation of the matrices for this study began on May 29, 2024, and their measurement was completed on June 4, 2024. It should be noted that the matrices were organized and generated in *Microsoft Excel* and subsequently processed in the *UCINET* software, whose efficiency in constructing collaboration networks for bibliometric research has been consolidated by results reported in several studies, thereafter, the visualization of the social networks was carried out through sociograms generated by the *NetDraw software*, which is specifically designed for the drawing and illustration of matrices (Ferreira & Silva, 2019).

It is further noted that the word cloud was generated using *Word Art*. Accordingly, the academic production, the structure, and the formation of the actors' networks were examined based on the results of the social networks considered in this research. These cooperation networks comprised co-authorship networks, institutional collaboration networks, and keyword co-occurrence networks. To enhance understanding and clarity, Figure 1 was developed to highlight the methodological pathway of this study.

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Figure 1. Methodological Pathway

4 ANALYSIS AND DISCUSSION OF RESULTS

This section addressed the analysis and discussion of the 52 articles on the theme of dam failures from the perspective of the Mariana and Brumadinho cases. Figure 2 highlights the eight periods identified in this research, in which publications on the central theme of this study were found.

Figure 2. Periods

Observing Figure 2, it is evident that the theme under investigation, although a subject that has recently gained prominence in the academic literature, particularly in Brazil, due to the cases of Mariana and Brumadinho (Primo et *al*., 2021; Sousa, Santos de Araújo & Barbosa, 2021), shows a slight tendency of decline within the Brazilian scientific sphere, based on the articles published in journals indexed in the SPELL database. This finding contrasts with what has been observed in similar academic studies, which indicate that the theme of dam failures tends to expand within the scientific literature rather than decrease (Reis et *al*., 2020; Costa, Knop & Felippe, 2021; Sousa, Santos de Araújo & Barbosa, 2021).

The result shown in Figure 2 may be associated with the following factors: the year 2024 is not yet complete, which influences the apparent decline in the central theme of this study, thus, if the year 2024 were excluded, it is likely that research on the subject under analysis would show a tendency

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to grow, furthermore, the theme of dam failures, under the perspective of the cases of Mariana and Brumadinho, may be further encouraged in other fields of knowledge, such as Geosciences and Law, thereby influencing and contributing to broader publication and dissemination within academia. At the same time, it is emphasized that Administration, Accounting, and Tourism are the fields of knowledge that stand out in terms of the dissemination and proliferation of research on dam failures in global academia (Costa, Knop & Felippe, 2021), therefore, journals linked to these areas of knowledge constitute appropriate and relevant channels for highlighting and disseminating this theme within Brazilian academic research.

Figure 3 presents the Brazilian scientific journals that published studies on the research topic investigated in this study.

Journal	Acronym	Qualis Capes (2017-2020)	Publishing institution	Articles	%	Zone
Revista de Estudos Organizacionais e Sociedade	Farol	A4	UFMG	3		
Revista Catarinense da Ciência Contábil	RCCC	A3	CRC (SC)	3		
Revista de Contabilidade e Organizações	RCO	A3	USP	3		
Revista Mineira de Contabilidade	RMC	A4	CRC (MG)	3		
Administração Pública e Gestão Social	APGS	A3	UFV	2		
Cadernos EBAPE.BR	CEBAPE	A2	FGV (RJ)	2	50%	1
Organizações & Sociedade	O&S	A2	UFBA	2		
Revista Eletrônica de Administração	REAd	A3	UFRGS	2		
Revista Reuna	Reuna	A4	UNA	2		
Revista de Administração, Contabilidade e Sustentabilidade	Reunir	A4	UFCG	2		
Revista de Contabilidade e Controladoria	RC&C	B1	UFPR	2		
Administração: Ensino e Pesquisa, Amazônia, Organizações e Sustentabilidade, Brazilian Business Review, Contabilidade Vista & Revista, Contexto - Revista do Programa de Pós-Graduação em Controladoria e Contabilidade da UFRGS, Environmental and Social Management Journal, Estudos de Administração e Sociedade, Gestão & Regionalidade, Gestão e Sociedade, Internext - International Business and Management Review, Marketing & Tourism Review, Pensar Contábil, Revista Brasileira de Inovação, Revista Ciências Administrativas, Revista Contemporânea de Contabilidade, Revista de Administração Contemporânea, Revista de Administração da UFSM, Revista de Administração Mackenzie, Revista de Administração Pública, Revista de Administração, Contabilidade e Economia da FUNDACE, Revista de Gestão Ambiental e Sustentabilidade, Revista Enfoque: Reflexão Contábil, Revista Gestão & Conexões, Revista Gestão & Planejamento, Revista Pensamento Contemporâneo em Administração e Revista Universo Contábil.				26	50%	2

Figure 3. Journals

Source: Research data (2024)

Examining Figure 3, it is observed that the most productive journals regarding research on the central theme of this study, according to the SPELL database, were: Farol, RCCC, RCO, RMC, APGS, CEBAPE, O&S, REAd, Reuna, Reunir, and RC&C. These scientific journals belong to zone 1, which stands out in the academic production on the subject under investigation in this research. It is also worth noting that 26 additional academic journals were identified, comprising zone 2 of this study; however, these journals published only once on the central topic of this research, placing them in zone 2. Interestingly, zone 1 includes the 11 most prolific journals, which were responsible for publishing 26 articles, while zone 2 encompasses 26 journals that contributed 26 publications, meaning that each zone (1 and 2) accounted for 50% of the total publications.

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In summary, it can be understood that the data collected and illustrated in Figure 3 show the existence of a small core of scientific journals (zone 1) that address the central theme of this research more extensively, and a more peripheral group of journals represented by zone 2. That said, it is observed that in these zones, an increase in the number of academic journals corresponds to a decrease in the publication productivity on the investigated topic, this observation aligns with *Bradford's* Law, which states that the decreasing order of study productivity on a given subject across scientific journals allows for the establishment of zones of productivity grouped exponentially (Machado Junior *et al.*, 2016b).

Still regarding *Bradford's* Law, it allows for measuring the level of relevance of journals engaged in publishing specific academic topics. Thus, academic journals with a higher number of published articles on a given subject tend to establish a core that supposedly reflects higher quality and greater importance for that specific theme. Therefore, according to *Bradford's* Law, the initial academic works on a particular topic are submitted to a limited number of journals. The acceptance and publication of these scientific papers then encourage other researchers in the same field to submit their articles to these journals (Machado Junior *et al.*, 2016b).

Synchronously, other scientific journals observe the evolution of the theme and begin publishing research on this subject (Machado Junior *et al.*, 2016b), enabling those journals currently positioned in zone 2 of productivity to advance in their academic output on the core topic of this research, this progression may later allow them to move into zone 1 of prolificacy, thereby being considered, retrospectively, as academic journals that play a more direct role in the publication, dissemination, and socialization of scientific knowledge on the theme under investigation.

It is also worth noting that, with the growing interest in the topic and its corresponding academic advancement, it becomes possible to establish a core of more productive academic journals for this subject (Machado Junior *et al.*, 2016b), accordingly, for this research, it is reiterated that this core of journals was composed of the following scientific periodicals: Farol, RCCC, RCO, RMC, APGS, CEBAPE, O&S, REAd, Reuna, Reunir, and RC&C. Thus, it can be understood that these journals are the most sought after by authors to publish their results and contributions regarding the theme of dam failures, particularly under the perspective of the Mariana and Brumadinho cases within Brazilian academia.

Table 1 presents the 123 authors who published academic works on the central theme of this study, highlighting the 13 most prolific researchers: Armindo dos Santos de Sousa Teodósio, Carolina Machado Saraiva, Cintia Rodrigues de Oliveira Medeiros, Jussara Jéssica Pereira, Pamella Thaís Magalhães Ferreira, Diego Luiz Teixeira Boava, Elizeu Barroso Alves, Fernanda Maria Felício Macedo, Franciele Machado de Souza, Luiz Panhoca, Viviane Theiss, Tatiane Lúcia de Melo, and Liliane de Oliveira Guimarães. It is also worth noting that 110 authors published only one article.

This finding is consistent with what is established by *Lotka's* Law, which emphasizes that many academics publish only a few studies on a given subject—these authors being regarded as less mature within this specific theme in the scientific literature—while only a few researchers are more prolific on the same topic, thus being considered the most relevant scholars for the referenced theme in academia (Souza & Ribeiro, 2013; Pinheiro & Almeida, 2020).

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Table 1. Authors

Author	HEI*	Year of Publication	Articles
Armindo dos Santos de Sousa Teodósio	PUC (MG)	2017 e 2022 (2)	3
Carolina Machado Saraiva	UFOP	2018, 2019 e 2021	3
Cintia Rodrigues de Oliveira Medeiros	UFU	2018, 2019 e 2024	3
Jussara Jéssica Pereira	FGV (SP)	2019, 2022 e 2023	3
Pamella Thaís Magalhães Ferreira	UFOP	2018, 2019 e 2023	3
Diego Luiz Teixeira Boava	UNINTER	2023 (2)	2
Elizeu Barroso Alves	UFOP	2017 e 2019	2
Fernanda Maria Felício Macedo	UFPR	2019 e 2020	2
Franciele Machado de Souza	UFPR	2019 e 2020	2
Luiz Panhoca	UFLA	2018 e 2023	2
Viviane Theiss	UFSC	2021 e 2022	2
Tatiane Lúcia de Melo	PUC (MG)	2022 e 2023	2
Liliane de Oliveira Guimarães	PUC (MG)	2022 e 2023	2
110 autores publicaram 1 artigo		1	

Source: Research data (2024)
Note: * Higher Education Institutions (HEIs) of the author's most recent publication

Among these most productive authors, all had their respective publications on the central topic of this research, as indexed in the SPELL database, disseminated in Brazilian scientific journals from 2017 onward. It is also worth noting that these 13 most proficient scholars are affiliated with institutions in the South and, particularly, the Southeast regions of Brazil, within this region, most institutions are located in the state of Minas Gerais, which is where the environmental disasters in Mariana and Brumadinho occurred (Pacheco, Henriques & Ribeiro, 2020; Primo *et al.*, 2021). Therefore, it can be understood that the most prolific authors on the core subject of this research are from HEIs located in Minas Gerais, and this affiliation may be a determining and influential factor in their prominence in publishing on the main theme of this study.

It is also worth commenting on *Price's* Law of Elitism, which allows for the identification of the elite group of researchers on a given subject, this law is mathematically represented by the expression $\sqrt{n}$, where "n" denotes the total number of authors who have published studies on a specific topic, generating approximately half of all publications. Specifically, the most prolific scholars account for about half of the publications on a chosen academic theme. Accordingly, this law is also known as *Price's* Square Root Law (Hayashi, 2023).

Thus, for this research, "n" is 123, and its $\sqrt{n}$ is approximately 11, which is close to the total number of most productive authors identified in this study. Consequently, it can be understood that the 13 scholars highlighted in Table 2 of this investigation are not only the most representative but also constitute the elite of scientific production on the topic of dam failures, particularly from the perspective of the Mariana and Brumadinho cases in Brazilian academia, based on journals indexed in the SPELL database, their prominence may also influence their respective centrality within the co-authorship networks analyzed in this research (Ribeiro, 2023a).

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Figure 4 depicts the co-authorship networks of this research, which consist of 284 links and 123 nodes. It is noteworthy that, to identify the authors responsible for mediating the flow of information (David et *al.*, 2022) on the core topic of this study, the betweenness centrality measure was employed.

Figure 4. Co-authorship Networks

Source: Research data (2024)

Accordingly, the researchers who stood out in terms of this centrality measure, in descending order of importance, were: Jussara Jéssica Pereira, Pamella Thaís Magalhães Ferreira, Cintia Rodrigues de Oliveira Medeiros, Carolina Machado Saraiva, Armindo dos Santos de Sousa Teodósio, Fernanda Maria Felício Macedo, Diego Luiz Teixeira Boava, and Viviane Theiss. This highlights that these authors shorten the paths between any two other researchers who pass through them, exhibiting the highest *betweenness*. Consequently, the scholars emphasized in Figure 4 are considered "bridges" and "guides," as they possess the "power" to mediate the flow of information among researchers within the co-authorship networks (Grácio, 2018; Ribeiro, 2023a).

It should also be noted that, among these eight most central authors identified in Figure 4, all are also among the most prolific and simultaneously constitute the elite of scholars publishing on the central topic of this research in Brazilian academia, according to journals indexed in the SPELL database, this reinforces the importance of scientific production proficiency as a potential factor in achieving prominence within co-authorship networks (Ribeiro, 2023b), as observed in this study.

It is emphasized that when the density index approaches 1 (one), it demonstrates that the pattern of interactions among actors in this case, the researchers is harmonious, thereby facilitating the flow of information and scientific knowledge (Farias Filho, Williams dos Santos & Conde, 2016), however, this statement is not validated in this study, since the density of the co-authorship networks was measured at 0,0195, in other words, only 1,95% of the relationships among the scholars were effectively established, thus, it can be said that the social network of the 123 authors is characterized by low density, weak internal cohesion, dispersion, and the presence of structural holes among research groups, this directly influences the fluidity of the flow of information and academic knowledge (Williams dos Santos & Farias Filho, 2016;

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Ribeiro, 2020), within the HEIs to which each author is affiliated and, consequently, concerning the theme of dam failures from the perspective of the Mariana and Brumadinho cases in Brazilian scientific literature, based on journals indexed in the SPELL database.

Table 2 presents the 32 HEIs that published articles on the core theme of this research, highlighting the 10 most productive institutions: UFOP, FGV (SP), PUC (MG), UFRJ, UFLA, UFMG, UFPR, UFSC, USP, and UFU. Similar to what was observed in Table 1, a comparable result is found regarding Brazilian regions, more specifically, the most prolific HEIs are located in the South and, particularly, in the Southeast of the country, with the state of Minas Gerais leading the way, this underscores, confirms, and reiterates the importance of the authors and their respective research groups in the dissemination, diffusion, and socialization of the theme of dam failures, particularly under the perspective of the Mariana and Brumadinho cases, within Brazil, across the states of the federation, and consequently within the HEIs, in the academic literature context.

Table 2. HEIS

HEIS	State	Region	Articles
Universidade Federal de Ouro Preto (UFOP)	Minas Gerais	Sudeste	8
Fundação Getulio Vargas de São Paulo (FGV-SP)	São Paulo	Sudeste	5
Pontifícia Universidade Católica de Minas Gerais (PUC-MG)	Minas Gerais	Sudeste	5
Universidade Federal do Rio de Janeiro (UFRJ)	Rio de Janeiro	Sudeste	5
Universidade Federal de Lavras (UFLA)	Minas Gerais	Sudeste	4
Universidade Federal de Minas Gerais (UFMG)	Minas Gerais	Sudeste	4
Universidade Federal do Paraná (UFPR)	Paraná	Sul	4
Universidade Federal de Santa Catarina (UFSC)	Santa Catarina	Sul	4
Universidade de São Paulo (USP)	São Paulo	Sudeste	4
Universidade Federal de Uberlândia (UFU)	Minas Gerais	Sudeste	3
7 HEIs published 2 articles			2
15 HEIs published 1 article			1

Source: Research data (2024)

It is further noted that these HEIs also stood out in review studies focusing on topics within the field of Administration in Brazilian academia (Resende, Demo & Nascimento, 2019), reinforcing their relevance in the advancement, proliferation, and dissemination of scientific knowledge not only regarding the central theme of this study but also in matters related to the field of Administration and related areas. Finally, it is emphasized that the prominence of the HEIs highlighted in Table 2 may represent an important factor for their potential centrality and visibility within HEI collaboration networks (Ribeiro & Corrêa, 2022).

Figure 5 illustrates the HEI collaboration networks, which were composed of 56 links and 32 nodes. It should be noted that the measure used to highlight the HEIs in Figure 5 was betweenness centrality, since this is a global measure of centrality that assesses the relationships among actors in this case, the HEIs across the entire institutional social network, this allowed for the identification of the HEIs with the greatest control over relationships within the cooperation network and, therefore, over the mediation of the informational and knowledge flow on the main theme of this research (Silva & Araujo Soares, 2021; Ribeiro, 2023a). Based on this, the HEIs ranked in descending order of relevance were: UFJF, FGV (SP), UFRJ, UFLA, USP, UFOP, and UFSC.

Figure 5. HEI Collaboration Networks

Source: Research data (2024)

Among these HEIs, all were ranked among the most productive in this study, with the exception of UFJF, although UFJF did not appear among the most prolific institutions, it stood out as the one with the highest *betweenness*, due to its interactions with four other institutions, this positioning enhanced its role as an intermediary HEI for the flow of scientific information and knowledge, alongside the other institutions highlighted in Figure 5, regarding the theme of dam failures from the perspective of the Mariana and Brumadinho cases in Brazilian scientific literature, based on journals indexed in the SPELL database.

It is also noted that there is a giant component in Figure 5, which is composed precisely of the HEIs with the highest betweenness centrality, consequently, it can be understood that the majority of HEIs within this giant component emphasize the main flow of information and knowledge within the HEI social network, this may serve as an indicator of the maturity of the research (Köhler, Digiampietri & Almeida, 2019) on the central theme of this study, conducted by researchers affiliated with the HEIs that form the giant component in Figure 5.

However, the density of the HEI social network was calculated at 0.0605, corresponding to 6.05% of the relationships actually established among the 32 HEIs in this study, consequently, it can be understood that the collaboration network of the institutions in this research has low density, high dispersion, and limited internal cohesion among the HEIs, this directly impacts the flow of information and overall knowledge within the social network (Farias Filho, Williams dos Santos & Conde, 2016; Williams dos Santos & Farias Filho, 2016; Ribeiro, 2017), particularly regarding the theme of dam failures from the perspective of the Mariana and Brumadinho cases in Brazilian academic literature, based on journals indexed in the SPELL database.

Figure 6 presents the word cloud of this research, which was created from the 155 keywords identified in the 52 studies focused on the theme of dam failures from the perspective of the Mariana and Brumadinho cases.

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Figure 6. Word Cloud

That said, the words most frequently used by the 123 authors in this study, in order of appearance across the 52 articles, were: disaster, Samarco, corporate, environmental, crime, dam, mining, Brumadinho, sustainability, environmental, social, Mariana, legitimacy, responsibility, social, theory, report, study, event, *management*, rupture, and corporate. Accordingly, and in line with *Zipf's Law*, it can be observed and understood that the words highlighted in Figure 6 present an ordered and hierarchical list of the most relevant terms. This facilitates comprehension of the central theme of this research and also indicates the main topics addressed in the 52 studies identified in this investigation (Souza & Ribeiro, 2013; Machado Junior *et al.*, 2016b; Pinheiro & Almeida, 2020) on the subject of dam failures from the perspective of the Mariana and Brumadinho cases in Brazilian academia.

Figure 7 complements Figure 6 by depicting the keyword networks of the 52 articles identified in this research, the network was organized into 636 links and 155 nodes (top view), and 474 links and 101 nodes in the giant component of Figure 7, representing the largest *cluster* of the keyword networks in this study. It is important to note that the 52 articles analyzed contained a total of 155 unique keyword occurrences, following the criteria of not distinguishing between uppercase and lowercase letters, while singular and plural forms of keywords were treated as distinct (Favaretto & Francisco, 2017). The main *cluster* in Figure 7 was composed of the 101 keywords most frequently used across the 52 articles in this study.

Figure 7. Keyword Social Networks

It is noteworthy that for the keyword social networks, degree centrality was used to highlight the most relevant keywords in the context of their connections with other keywords (Ribeiro, 2023a) and, simultaneously, to indicate the extent to which a given term is impactful and central to the focus of this investigation (Urbizagástegui-Alvarado, 2022).

In this context, the most central keywords in this research, in descending order of value, were: Samarco, corporate crime, Brumadinho, mining, corporate social responsibility, disaster, sustainability reports, Mariana, environmental disasters, dam rupture, legitimacy, event studies, disasters, reputation, legitimacy theory, Vale, corporate crimes, and dam. Based on this, it can be seen that these keywords may be considered *hot topics* regarding the theme of dam failures from the perspective of the Mariana and Brumadinho cases in Brazilian academia, consequently, these results highlight, guide, and indicate the current trajectory of studies on this subject, also providing potential directions for future research (Primo *et al.*, 2021).

Given this information, it can also be understood that these keywords, due to their high centrality scores, exert significant influence over the other terms (keywords) investigated. It is also observed that the keywords with the highest *degree* centrality correspond closely to the word cloud (see Figure 6), thus aligning with *Zipf's* Law. Accordingly, these keywords reflect the primary concerns of the authors and their respective studies regarding the central theme of this research. As such, these most central keywords are more strongly connected to studies on the topic under investigation, impacting the evolution, maturation, and continuity of research on this subject (Urbizagástegui-Alvarado, 2022) within Brazilian academic literature, based on journals indexed in the SPELL database.

It should be noted that the keywords Samarco, Brumadinho, Mariana, and Vale stood out with the highest *degree* centrality in the keyword social networks because they were used in the search for studies on the central theme of this research. Therefore, in addition to being intrinsic to the subject under investigation, their prominence in the giant component of Figure 7 is also due to their use in the article search process for this topic.

Returning to the keywords with the highest degree centrality that is, the keywords with the greatest number of connections (associations) with other keywords (Ribeiro, 2023a), it is observed that the most frequently occurring interactions in the 52 articles analyzed in this research, in descending order of occurrence, were between: corporate crime and Samarco; corporate crime and *management*; corporate crime and resource-dependence; resource-dependence and *management*; dam rupture and Samarco; disaster and Mariana; disaster and Samarco; legitimacy and Samarco; Samarco and Mariana; and Samarco and legitimacy theory. These findings demonstrate the inherent relationship of these terms (keywords) with the central theme of this research.

Furthermore, regarding centrality, it is emphasized that the keywords (terms) with lower centrality may encourage researchers to investigate them, generating new studies, subsequently, the publication of these new studies will relationally contribute to the growth and maturation of research on dam failures from the perspective of the Mariana and Brumadinho cases within Brazilian academia.

5 CONCLUSION

The objective of this study was to investigate the behavior and trends of scientific production on the topic of dam failures in Brazilian academic literature, from the perspective of the Mariana and Brumadinho cases. To achieve this goal, the research adopted a quantitative, descriptive, and exploratory approach, through

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a documental analysis of articles published in journals indexed in the SPELL database. The study sample comprised 52 articles, which were analyzed using bibliometric and sociometric methods and techniques.

The main results indicate that the topic of dam failures from the perspective of the Mariana and Brumadinho cases shows a declining trend in Brazilian academic literature, reaching its peak publication periods in 2019, the year of the Brumadinho environmental disaster and in 2022, with 10 studies published in national journals during each period. The most prolific scientific journals were Farol, RCCC, RCO, and RMC, each with three publications, all classified in the A3 or A4 strata of the current Qualis system of the Coordination for the Improvement of Higher Education Personnel (CAPES).

Regarding the researchers, the most prolific and, consequently, the elite of scientific production, as, well as the most central to the core theme of this study, were: Jussara Jéssica Pereira, Pamella Thaís Magalhães Ferreira, Cintia Rodrigues de Oliveira Medeiros, Carolina Machado Saraiva, Armindo dos Santos de Sousa Teodósio, Fernanda Maria Felício Macedo, Diego Luiz Teixeira Boava, and Viviane Theiss. In this context, the most productive HEIs, which were also the most central to the core subject of this study, were: FGV (SP), UFRJ, UFLA, USP, UFOP, and UFSC. Concerning the social networks of authors and HEIs, it is emphasized that both exhibited low density, resulting in structural holes, weak ties, high dispersion, and limited internal cohesion, thereby impacting the flow of information and knowledge on the central theme of this research within Brazilian academia.

Regarding the most frequently used keywords by the 123 authors across the 52 articles in this study, the following stood out: disaster, Samarco, corporate, environmental, crime, dam, mining, Brumadinho, sustainability, environmental, social, Mariana, legitimacy, responsibility, social, theory, report, study, event, *management*, rupture, and corporate. Complementing this information, the keywords with the highest *degree* centrality in this study were: Samarco, corporate crime, Brumadinho, mining, corporate social responsibility, disaster, sustainability reports, Mariana, environmental disasters, dam rupture, legitimacy, event studies, disasters, reputation, legitimacy theory, Vale, corporate crimes, and dam.

At a macro level, it is observed that the keywords used by the researchers in their respective studies form the theoretical corpus of the topic of dam failures from the perspective of the Mariana and Brumadinho cases, this helps to better understand, and, consequently, comprehend how information and knowledge on this subject are published, disseminated, and socialized within Brazilian academia, based on journals indexed in the SPELL digital library.

Thus, the academic implications of this study lie in its investigative findings, which are reflected in the analysis of contemporary academic production published in journals indexed in the SPELL database, as well as in the identification of the behavior and trends of the central theme of this research within Brazilian academia. The scientific consequences of this research are also evident in the examination of the structures and formations of social networks among the actors involved in the construction of scientific knowledge, as well as in anticipating future research trends on the core topic of this study in Brazil. Regarding practical implications, this research can serve as a reference for companies, particularly, those in the mining sector, by guiding a better understanding and comprehension of the subject under investigation for the management of these organizations.

Finally, this research contributed to the state of the art on the topic of dam failures from the perspective of the Mariana and Brumadinho cases in Brazil, based on journals indexed in the SPELL database. However, this also represents a limitation of the study, as the article search was restricted solely to the SPELL database. Therefore, it is recommended that future research expand on this study by using additional national and international databases, such as CAPES Journals, *SciELO*, *EBSCO*, *Web of Science*, and *Scopus*. It is also advisable to employ new methods for analyzing the social networks of actors, such as co-citation analysis,

closeness centrality, among others. Another suggestion is to conduct a Systematic Literature Review focusing on the most central keywords (terms) identified in Figure 7, which underpin and guide the core theme of this research.

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