ENVIRONMENTAL VULNERABILITY AND TECHNOLOGICAL RISKS IN COLLAPSE AND BREAK OF DAMS IN BRAZIL: LESSONS FROM MARIANA (MG) DISASTER

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Abstract

The objective of the study is to analyze the technological disaster dam break and check the environmental vulnerability of populations inhabiting these areas. To this end, use shall be using bibliographic and documentary studies from the case study – Dam break of Fundão and Santarém, in the municipality of Mariana (MG).

Keywords: dam, technological disasters, civil protection, prevention, protection.

1. INTRODUCTION

Due to its geographical and climatic characteristics and the vast water and mineral resources, Brazil has developed the infrastructure area of dam construction, moved also for reasons of economic development policies.

According to Mello (2011), one of the first dams built in Brazil in the late sixteenth century, was the dam of Apipucos, located in the current urban area of Recife (capital of Pernambuco), and appearing on city maps in 1577. The original dam was extended and strengthened by the Dutch, so that an important access route to the center of Recife was built, and maintained till the present day, renamed Açude de Apipucos, as can be seen in Figure 1.

Since then, especially between the years 50 and 80 of the twentieth century, it was built in the country hundreds of dams, responsible for major environmental impacts and forced displacement of populations, including the indigenous and riverine inhabitants. These constructions have contributed significantly to intensify the environmental and social vulnerability of these areas, considering that most of these dams were built in the period when there was virtually no environmental legislation, except the Water Code - Decree No. 24.643 / 1934, the old Forest Code - law nº. 4.771 / 1965 (repealed by the New Forest Code - law nº. 12,651 / 2012) and the Mining Code - Decree-law nº. 227 of 02/28/1967, which is in force until the present day.

Moreover, there was not, by the public authorities, the concern with the issue of safety and operation of dams. This concern only becomes evident after the occurrence of various disasters, as occurred in 1977 in Euclides da Cunha and Armando Salles de Oliveira dams, in State of São Paulo, when it was issued the first decree regarding dam safety but that was not regulated and so was not implemented.

Figure 1 - Weir of Apipucos - the oldest dam in Brazil

Source: Mello 2011

2. SOME CONSIDERATIONS ON DAMS IN BRAZIL

As explained by Esposito and Duarte (2010), there is in Brazil several types of reservoirs of different dimensions and destinations of use, for example, infrastructure dam for water control, power generation, landfills or dams for retaining industrial waste and ore tailings containment dams.

ANA's data (2015) indicate that currently exist in Brazil about 14,966 dams registered in total, and that number only 2,097 were classified by risk category, while 1,681 were classified in the category of the potential damage associated, representing, respectively 14% and 11% of the total. Another important fact is that from these 14,966 registered dams, 7,353 are located in São Paulo State, 3,070 are installed in Rio Grande do Sul, and 1,061 in Minas Gerais, which represents 76.73% of the registered dams.

The ANA report noted also that in 2014, there was the realization of any regular inspection in just 402 dams, and currently 153 dams have Emergency Action Plan-PAE, while other 92 had the PAE elaboration process. In addition, in 2014, there were 5 disasters - the largest number of accidents since the year 2011 - with 9 fatalities and 6 incidents.

These data only confirm that the safety of dams in Brazil needs to be better evaluated, especially about social and environmental vulnerabilities.

2.1. The Regulatory Framework of Dams in Brazil

The first legislation in Brazil on dams were issued after the congress held by ICOLD - International Commission on Large Dams, in New Delhi, in 1979, in which it was decided the need to make efforts to increase the safety of dams. Also mentioned was the increased number of dams that were being built in countries with little (or no) experience in this area of dam engineering. Since then, in Brazil, although timidly, it appears the first standards focused on dam safety, and which culminated in the publication of the National Dam Safety Policy - Law nº. 12.334 / 2010, considered the regulatory framework of the dams in the country.

They are also used in Brazil to guide the issues relating the dams, the following laws: Law No. 12,608 / 2012 National -Politics Protection and Civil Defense (PNPDEC), Law 9.433 / 1997 - National Water Resources Policy, Law No. 9,984 / 2000 - creation of the National Water Agency (ANA), Law No. 6.938 / 1981 National -Politics Environment (PNMA), the Mining Code - Decree-Law No. 227/1967 and the 1988 Federal Constitution.

Other standards that are applied to the security and implementation of dams are:

a) Resolutions of the National Water Resources Council - CNRH: Res No. 143 of 10/07/2012 and Res No. 144 of 10/07/2012;

b) Resolutions of the National Water Agency - ANA: Res No. 742 of 27/10/2011 and 09/04/2012 Res No. 91;

c) Ordinance No. 526 of 12.09.2013, and Ordinance No. 416 of 03/09/2012, the National Department of Mineral Production - DNPM.

d) CONAMA Resolution: Res 237/1997 (Environmental License), Res 307/2002 (Civil Construction waste)

e) Technical Standards (NT-Normas Técnicas) issued by the Brazilian Association of Technical Standards-ABNT (Associação Brasileira de Normas Técnicas), among which may be cited: NBR 13028 ABNT / NB 1464, NBR 13029/2006 ABNT / NB 1465, NBR 1057 NB1025 / 2014.

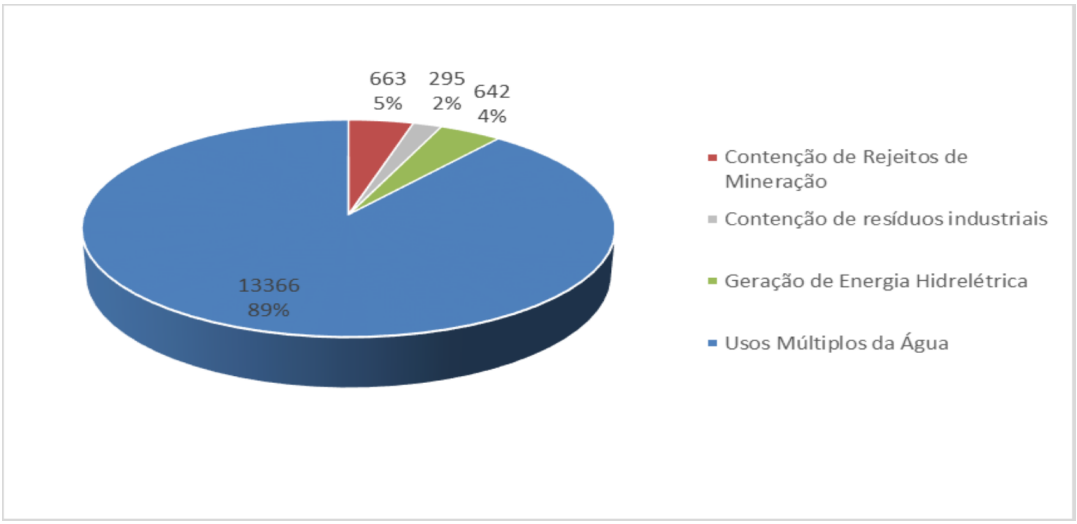
3. TAILINGS DAMS IN BRAZIL

Mining activities represents an important segment in the national economy since the fifteenth century, when it began in Brazil the gold extraction, arising from Mina da Passagem, in Mariana (MG).

From the 30´s, with the increasing production and constant conflicts of land use and water because of soil and water contamination, arose the need to create mechanisms to better allocation of the waste resulting from this activity, which led to the construction of the first dam to contain tailings, which were built without a lot of technical care and safety.

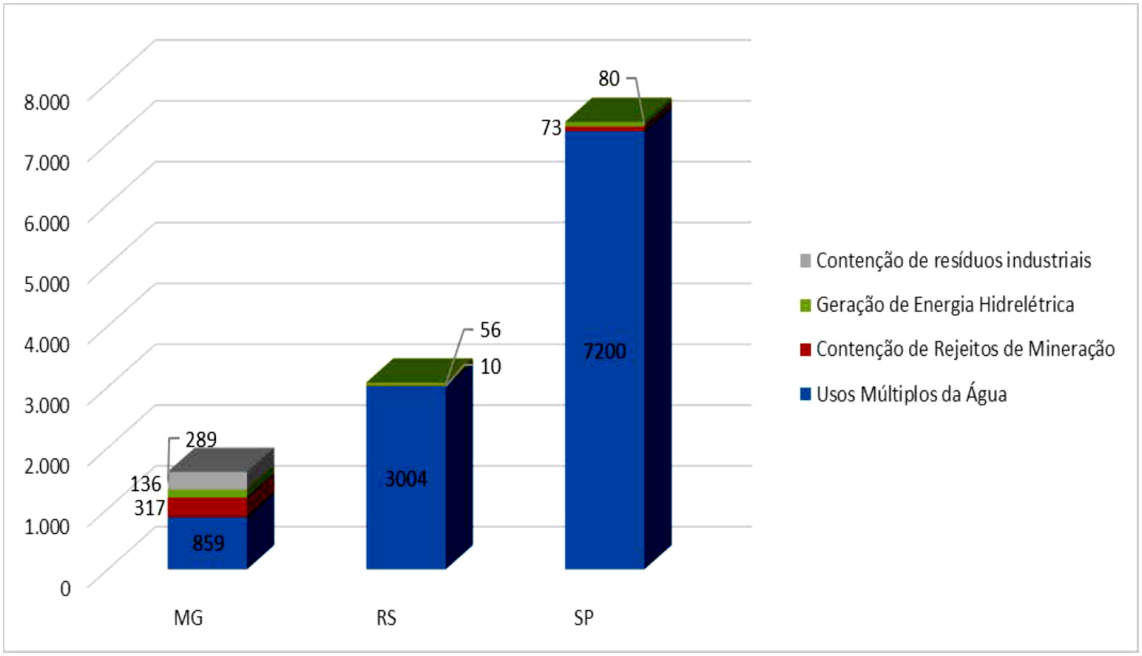
Data of Dam Safety Report, published by the National Water Agency - ANA (2015) indicate that the total of 14,966 dams registered, 633 are used to containment of mining waste, and in the State of Minas Gerais are concentrated many of these dams – they are 317, followed by the state of São Paulo, with 73 dams, as can be seen in Figure 2 and 3, respectively.

Figure 2 – Dams registered for primary use



Source: ANA, 2015

Figure 3 – Dams registered for primary use in Minas Gerais (MG), São Paulo (SP) and Rio Grande do Sul (RS) State.



Source: ANA, 2015

3.1. The Risks and Environmental Dangers of Tailings Dams in Brazil

Despite the technological progress in the construction of dams since the 40s, the disasters caused by disruption / break always permeated the dams and their surroundings, causing major environmental damage, economic, social and human losses, especially in the regions and populations located in valleys and downstream.

The main causes identified by Avila and Sawaya (2011) for the occurrence of general dam burst disaster are due, among other factors: the non-proper application of technology, bad preparation of projects, lack of supervision and control during

construction, the neglect of the vital features incorporated in the construction phase, the non-implementation of effective actions aimed to ensure structural safety, and the failure of owners and operators to adopt safety management procedures to reduce risks. They can also be incorporated into these causes, the lack (or absence) of inspection, supervision and control by the public agencies responsible for supervision during the period of operation of the dams.

Another problem that contributes to increase the risk of dam break is linked to increased production of waste and the reduction of areas for its disposal, which requires, according to Avila and Sawaya (2011), the construction of increasingly high dams, such as the Tailings Disposal System Germano (Mariana-MG), the highest in the country, with approximately 155 meters and built in 1976 , in which were performed several hightenings since 1993, and had two dams of its complex - Fundão and Santarém tailings dams - broken on November 5, 2015, causing the worst environmental disaster in Brazil.

Given these sad events, the company began requiring from the public administration an increased and better control in the safety of these buildings, which resulted in the approval of the National Dam Safety Policy in 2010. However, this did not prevent new disasters caused by breakage / tailings collapse occurred in the country.

4. THE MAJOR TECHNOLOGICAL DISASTERS IN BRAZIL CAUSED BY RUPTURE / DAM COLLAPSE

The production of ore is considered an activity that causes great impact on the environment and society because of the risks that involves. In Brazil, the dams of mining waste caused in the past 30 years (1986-2015), about seven disasters with devastating effects on societies affected, among which deaths, environmental destruction, social and economic disruption. The major disasters in this period by breaking were:

- Disruption of Fernandinho (Rio Acima-MG) tailings dam in 1986, which caused the death of 07 people;
- Disruption of part of Macacos dam of the mining company Rio Verde Mineradora, in the district of Nova Lima (metropolitan region of Belo Horizonte) in 2001, which killed 05 company workers and left a mud river in the district;
- Disruption of the dam of industrial waste in Cataguases in 2003, which released 1.4 million liters of black liquor (residue from pulp production) and contaminated the Paraiba do Sul River and its streams, reached Rio de Janeiro State, interrupted water supplies and killed fishes and other animals that lived on the riverbanks;
- First breaking dam of Mineradora Rio Pomba Cataguases in 2006 in the city of Miraí (MG), responsible for the leak of 400 million liters of clay mud, mixed with iron oxide and aluminum sulfate which contaminated Rio Fubá, agricultural areas and pastures, and the death of fishes and other animals of the local fauna. (BALBI 2007).
- Second dam breaking of the mining Mineradora Rio Pomba Cataguases, in 2007, installed in the municipality of Miraí (MG), which spread about 2 million cubic meters of bauxite the in city and four other cities: Muriaé and Patrocínio de Muriaé, also in the Minas Gerais Zona da Mata (Forest zone), Laje de Muriaé and Itaperuna in Rio de Janeiro.
- Dam breaking of the tailing dam of Mineradora Herculano, on the Mine Retiro dos Sapecados in the city of Itabirito (MG) in 2014, that caused the death of 03 workers and environmental damage to streams of Rio das Velhas basin.

Disruption of Fundão and Santarém dams, in Bento Rodrigues district (Mariana-MG) in 2015, which released 62 million cubic meters resulting from iron mining tailings, destroying the district of Bento Rodrigues, and hit other districts and cities of Minas Gerais and Espírito Santo, and Rio Doce State Park, devastating the natural ecosystem of the Rio Doce and its tributaries.

Data from 2014 Dams of Security Report, released by the ANA (2015) indicate that between the years 2011 and 2014, after the publication of the National Dam Safety Policy, there were 10 disasters, and of this total, 03 occurred in mineral tailings dams. In the year 2014, there were 05 accidents, of which the most serious occurred on Dams B1 and B2, of the mining company Herculano, in Minas Gerais, which had probable cause internal erosion of the tailings dam.

5. THE CASE OF BREAK / COLLAPSE OF FUNDÃO AND SANTARÉM DAM OF TAILINGS DISPOSAL SYSTEM OF GERMANO SAMARCO MINERAÇÃO SA

On November 5, 2015, occurred the breakup of Fundão and Santarém dams, which are part of the Alegria Complex, belonging to the mining company Samarco SA, owned by Vale and Anglo-Australian BHP from which leaked 55 million cubic meters of waste resulting from the mining of iron. The district of Bento Rodrigues, located in the downstream of the dam, was devastated by the "sea of mud" as you can see in Figure 4, killing 19 people.

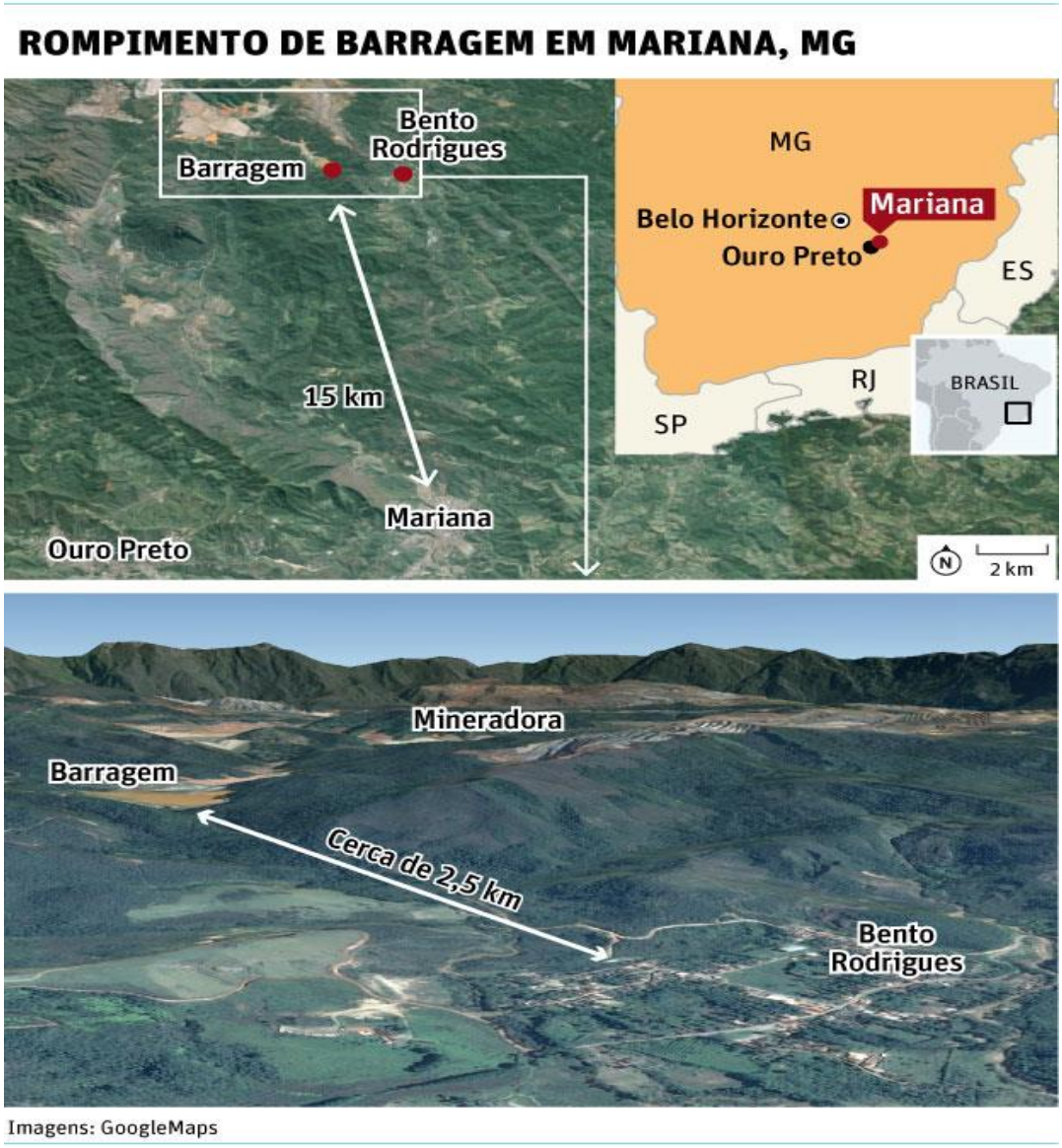
Also were affected the districts of Paracatu de Baixo and Paracatu de Cima, Bicas, Camargo, Santo Antônio das Pedras, Borba, Barretos and Campinas, and other municipalities in the state of Minas Gerais and Espirito Santo.

The "wave of mud" devastated Rio Doce State Park and the natural ecosystem of the basin of the Rio Doce, where, according to the IBGE (2015), lived about 3.3 million people, distributed among 228 municipalities in the basin, of which 202 are in Minas Gerais and 26 in Espírito Santo, with 47.75% of the population of the municipalities with up to 10,000 inhabitants living in rural areas.

The tailings dam rupture of the mining company Samarco SA, in Mariana (MG), also left without drinking water virtually all municipalities bordering the Rio Doce and coastal communities, rural and urban. This was considered the largest environmental disaster in Brazil in recent years.

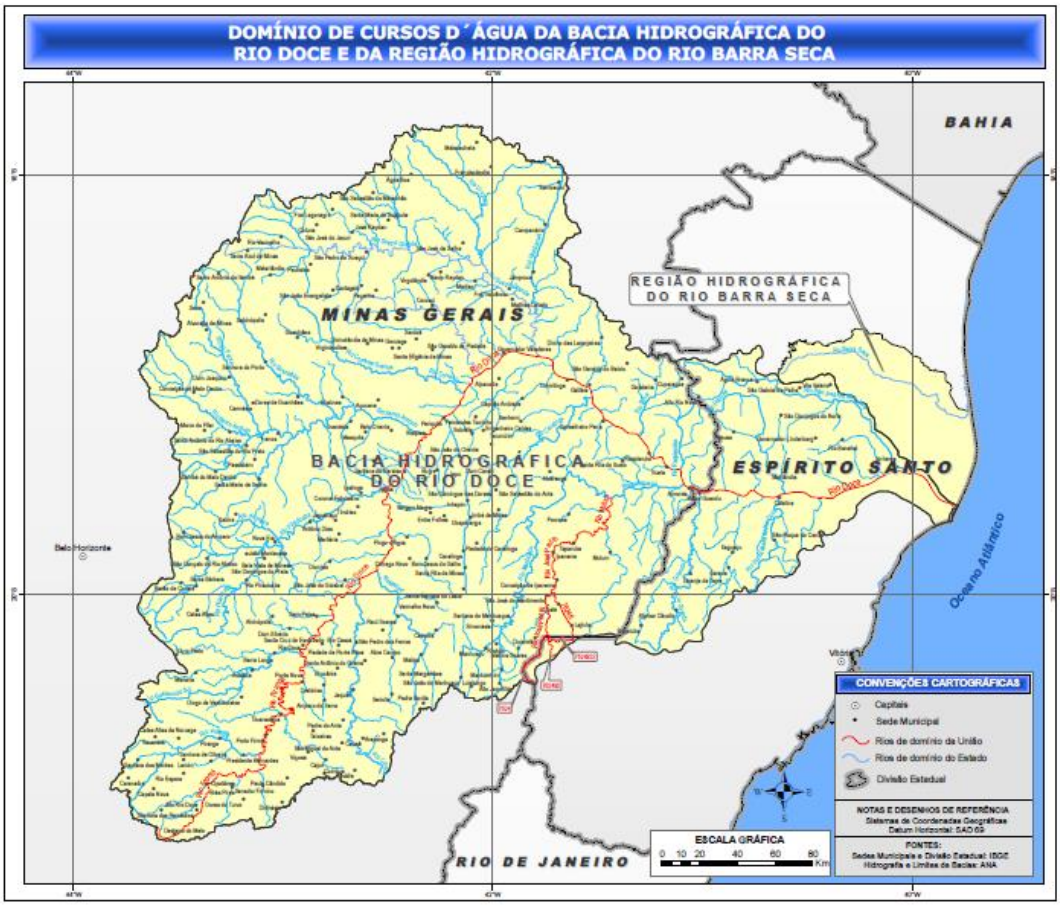
See, in Figure 5, the detailed map of the basin of Rio Doce.

Figure 4 - Disruption of Fundão and Santarém dam, in the district of Bento Rodrigues (Mariana / MG)



Source: Folha de São Paulo (2015)

Figure 5 - River Basin of Rio Doce and Hydrographic Area of Rio Barra Seca



Source: CBHRD (2007)

6. CONCLUSIONS

As in most environmental disasters, the most affected were the Maroons, the Krenak indigenous, riparian inhabitants from Rio Doce basin, and other poor urban living at permanent risk due to vulnerabilities and dangers to which they are exposed, due to the failure (or absence) of effective public policies for the prevention and mitigation of disasters.

In the case studied, although there are legislative provisions aimed at the dam safety, as well as the establishment of emergency plans, training and empowerment of people seeking protection in cases of disaster, and a warning system / alarm effective and fast, it seems that such rules were not followed, leaving once again fall on the people and environment, the burden.

On the other hand, despite the forecast of preventive action of civil defense in the National Protection and Civil Defence Policy, the Brazilian dam safety legislation refers to civil defense only in emergency situations, i.e., in relation to the liability of entrepreneur who will notify it in an emergency and, after initiating the emergency, in which time the coordinator of Ore Dam Emergency Plan, after declared the emergency, shall notify the

municipal civil defense, state and national. This demonstrates that the protection of society is secondary to the public authorities.

What is evident is that these disasters are pre-announced tragedies, bringing in their DNA uncertainty and risk, and inevitably leads to the fragility of the principles of precaution and prevention, as well as the state administrative structure, which keeps silent and conniving with economic constraints of high entrepreneurs, failing to act in the protection of civil society and the environment, and contributing to the increase in social and environmental vulnerabilities.

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