

Uranium exploration in Brazil and its consequences

Naldicea Cunha Fernandes da Silva^{1*}, Cleomacio Miguel da Silva², Livia de Souza Alexandre¹, Walkyria Carvalho¹, Jéssika Gouveia¹

¹Department of Administrative Sciences, University of Pernambuco, Brazil

²Department of Biology, University of Pernambuco, Campus Mata Norte, Brazil

*Corresponding author

Abstract—In the mid-70s, the former NUCLEBRAS carried out several studies to prospect for uranium minerals in the Northeast region. However, the anomalous occurrence of uranium and thorium located in the Agreste Semiárido region of Pernambuco, in the Pernambuco municipalities of Pedra and Venturosa drew the attention of technicians. However, after detailed studies, it was found that, despite the high concentrations of uranium and thorium, the occurrences were punctual, which made its extraction economically unfeasible. Despite being considered economically unviable, the inhabitants of the municipalities of Pedra and Venturosa are subject to high levels of natural radiation, which can result in damage to health. In Brazil, the exploration of radioactive ores is the responsibility of the Federal Government, with the National Nuclear Energy Commission (NNEC) being responsible for the administration of such resources, with the Nuclear Industries of Brazil (NIB) responsible for mining activities. Considering Brazilian law, NNEC is also responsible for radioactive deposits considered economically unviable, as it is a regulatory and supervisory body for all nuclear activities in the country. Thus, and within this context, the present study aimed to research, under Brazilian law, the legal responsibility for the natural radioactive anomaly existing in the Pernambuco and Pedra de Venturosa municipalities. For this purpose, a bibliographic review search in the specialized literature was used. The results obtained showed that, legally, CNEN is responsible for the natural radioactive anomaly located between the municipalities of Pedra and Venturosa, and therefore, it must adopt mitigating measures of radiological protection in those municipalities.

Keywords—Environmental legislation, Natural Radioactivity, Nuclear Ore.

I. INTRODUCTION

Brazil has one of the largest uranium reserves in the world, which makes it possible to supply domestic needs in the long term and make the surplus available to the foreign market. In June 2001, Brazil registered the sixth largest uranium geological reserve in the world, with approximately 309,000 tons of U₃O₈ in the states of Bahia, Ceará, Paraná and Minas Gerais, among other occurrences. Prospecting studies and geological surveys were carried out in only 25% of the national territory (1). The country also has uraniferous occurrences associated with other minerals, such as those found in the Pitinga deposits in the State of Amazonas and the Carajás area, in the State of Pará, with an estimated additional potential of 150,000 tons. Brazilian geological reserves have evolved from 9,400 tonnes, known in 1975, to the current quantity,

which can be expanded with new prospecting and mineral research work (1).

Uranium is a mineral that exists in nature under different conditions (either as ore, or associated with other minerals, such as, for example, gold and phosphate), being used as the main input to produce the fuel of nuclear plants. It is worth mentioning the density of uranium compared to that of other energy sources. About 1 kg of uranium generates 50,000 kWh of electricity, while 1 kg of coal or oil generates 3 to 4 kWh (1). This makes uranium a highly valued element in the world, as an alternative source for the generation of electricity.

In Brazil, uranium reserves are 309,000 tons of uranium and comprise the deposits of Itataia, Ceará, with approximately 142,000 tons (where uranium is associated with phosphate), Lagoa Real, in Bahia, with 93,200 tons,

and other smaller deposits, such as Gandarela, in Minas Gerais (where gold is associated with uranium), Rio Cristalino, in Pará, and Figueira, in Paraná. The Lagoa Real-Mina de Caetité deposit has total reserves of 100,770 tons of uranium, a sufficient quantity to supply the Angra 1, Angra 2, Angra 3 plants and four other plants (4,000 MW) during the entire useful life of these plants. In Santa Quitéria (Ceará), with total reserves of 142,500 tons of uranium associated with phosphate, an industrial complex for the exploration of uranium phosphate will be implemented. The Caldas deposit, in Minas Gerais, has total reserves of 4,500 tons, while the Cachoeira deposit will yield 300 tons of concentrated uranium per year for 15 years (1).

In Brazil, uranium mining is done in the open. The only mine in operation is Caetité, in Bahia, which uses the leaching process, ultimately resulting in a uranium concentrate in the form of ammonia diuranate (DUA). There is a forecast for underground mining at the Cachoeira mine, due to the approval of the licensing request requested by the Nuclear Industries of Brazil (NIB), the only uranium processing company in the country (1). The exploration of the uranium associated with phosphate will be carried out at the Itataia mine, in Santa Quitéria (Ceará), by the private company Galvani, responsible for the exploration and commercialization of phosphate, the raw material for the manufacture of phosphate fertilizers and mineral salt for animal nutrition. The economic viability of Itataia's uranium depends on the exploration of the associated phosphate, that is, the extraction of uranium is conditioned to the mining and the improvement of the phosphate ore. As a by-product in this process, the uranium liquor will remain with NIB(1).

The Mineral Treatment Unit (MTU) in Caldas, in Minas Gerais, was the first mining and processing project for uranium ore to operate in Brazil. It consisted of an open pit mine, or treatment facilities and a metallurgical processing plant for the production of uranium concentrate and a sulfuric acid factory. The plant was designed for an annual production of ammonia diuranate (DUA) of 500 tonnes equivalent to U_3O_8 . The mining of uranium ore began in 1977 and the plant's operation was closed in 1995 due to economic unfeasibility. During this period, around 1,200 tons of U_3O_8 were produced (1).

Uranium exploration in Brazil was started in 1952 by the National Research Council (NRC). This led to the discovery of the first uranium deposits in Poços de Caldas and Jacobina. These activities were subsequently continued by the National Energy Commission / National Nuclear Energy Commission (NNEC), formed in 1962. The founding of NUCLEBRAS in late 1974 marked the

growing effort of the country's uranium exploration program. At that time, only the Poços de Caldas deposit was known as measurable resources (2). Due to the reorganization of the Brazilian nuclear program in 1988, all uranium exploration in the country was interrupted. Until then, eight areas with uranium reserves have been identified, namely, the Poços de Caldas plateau (Minas Gerais); Figueira (Paraná); Quadrilátero Ferrífero (Minas Gerais); Amarinópolis (Goiás); Rio Preto / Campos Belos (Goiás); Itataia (Ceará); Lagoa Real (Bahia); Espinharas (Paraná). The first uranium production in Brazil, at the Osamu Utsumi mine (Poços de Caldas deposit), started in 1982. Due to rising costs and reduced demand, this activity was put on standby between 1990 and 1992. The mine was restarted in 1993 but was stopped again in October 1995. The mine's accumulated production up to 1996 was 1241 tonnes of uranium. Currently, the Lagoa Real deposit is being prepared as a new producing mine (2).

Uranium is an element that has the peculiarity of being used to produce heat. For this reason, it has its greatest use in the nuclear industry, as fuel for thermal plants to generate electricity. Although it is not a renewable energy source, its use as an energy fuel is greatly optimized.

The Federal Constitution (3) maintained, in its art. 21, XXIII and in art. 177, the Union's monopoly for the entire uranium chain, from mining to electricity generation. In order to exercise it, there are two state-owned companies, one responsible for the research and mining of uranium, Nuclear Industries of Brazil (NIB), and the other for the generation of nuclear energy (Eletrobrás). With regard to the inspection of activities involving the mineral and the final destination of radioactive waste, this is the responsibility of the National Nuclear Energy Commission (NNEC), the federal authority that created Rule 1.13, Licensing of Mines and Mining Processing Plants Uranium and / or Thorium, grant authorization for mining. Given the magnitude of the environmental impacts of uranium mining as well as nuclear generation and, considering that it is a strategic sector for the country, both are subject to prior environmental licensing by IBAMA, according to Art. 4, IV, of the Resolution CONAMA 237/97 (4). However, other environmental agencies intervene during the process, such as state environmental agencies and the administration of the Conservation Unit, when necessary.

The Preliminary License is the first environmental license to be obtained, and for that purpose an environmental impact study must be submitted, as well as a recovery plan for the degraded area as established in art. 3 of Decree 97.632 / 89 (5). The following licenses are for

the installation of the enterprise and the last for operation. For each phase, specific studies must be submitted to the licensing body. Thus, as can be seen from the procedures briefly outlined above, due to the exploitation of nuclear mineral deposits significantly impacting the local ecosystem, national legislation imposes a careful licensing procedure, which, once completed, will require the environmental agencies to take steps to inspection of the activity, in compliance with the technical rigors imposed on its exercise.

In the case of the exploration of ores containing uranium, however, the procedure apparently extended, the current environmental legislation lacks technical specificities necessary for the safety of the environment and the health of the population, in addition to an inefficient inspection by the environmental agency, often resulting from lack of human resources, specific technical knowledge for the activity, and even technological resources. In this sense, it is important to have a specific rule regulating the licensing of uranium research and mining activities, such as CONAMA Resolution 23/94 (4) which deals with the environmental licensing of the seismic, prospecting, production and exploration phases. Oil and Gas.

Uranium ores for being radioactive must be handled with caution so as not to generate environmental damage, and in addition to all the known consequences of such damage, it will also incur huge costs for the entrepreneur himself with remedial and compensation measures. For this reason, it is increasingly necessary to reinforce internal environmental monitoring programs, which must be constant and monitor both the operation and the closure of the mine, as the main environmental problems are related to these stages. In both phases, the resources most affected are water, flora and soil.

In many cases, the recovery of areas degraded by uranium exploration consists of relocating contaminated soil, as well as preventing and controlling erosion, usually done with vegetation. However, complete recovery of the area is not always possible. Sometimes, the contamination has such a wide scope that the removal of all the contaminated soil becomes impracticable and may even impede the extraction of the mineral. Therefore, and within this context, the objective of this work was to carry out a bibliographic research, aiming to show the consequences of uranium exploration in Brazil.

II. METHODOLOGY

In the present work, the methodology of bibliographic survey in specialized literature was used, with emphasis on

the exploration of uranium and its consequences for the natural environment and for human beings, analyzing the phases of operation and decommissioning of uraniumiferous mines according to the current laws.

III. RESULTS AND DISCUSSION

3.1. Brief history of uranium exploration in Brazil

The systematic prospecting of radioactive minerals, initiated in 1952 by the National Research Council of Brazil (NRCB), led to the discovery of the first indications of uranium in Poços de Caldas (Minas Gerais) and Jacobina (Bahia). This phase of activities initially depended on foreign know-how. In 1955, technical cooperation agreements were signed with the government of the United States of America to recognize the potential of uranium in Brazil. In 1962, the recently created National Nuclear Energy Commission (NNEC) sought the collaboration of the French Center for Nuclear Studies (FCNS) in the organization of its Mineral Exploration Department (2). So, at the 1970s, more financial resources were made available for prospecting for radioactive minerals exclusively through NNEC. With the founding of NUCLEBRÁS in December 1974, the Brazilian government's efforts received a boost in the basic part of the nuclear program, namely, the development of exploration and mining of uranium deposits. When, in December 1975, Brazil and Germany signed the Cooperation Agreement in the Field of the Peaceful Uses of Nuclear Energy, the Osamu Utsumi mine, in Minas Gerais, was the only known and measured uranium deposit (2).

Due to the reorganization of the Brazilian nuclear program in 1988, all uranium exploration activities were interrupted in 1991. After a reorganization of the Brazilian nuclear program in 1988, uranium exploration activities were delegated to a special organization known as "Urânio do Brasil SA", which was organized as a subsidiary of Nuclear Industries of Brazil (NIB), a holding company responsible for planning, programming and executing the nuclear fuel cycle. Currently, only NIB is responsible for all nuclear fuel cycle management activities in Brazil. During the period from 1990 to 1992, uranium production was on standby. Production restarted at the end of 1993, and stopped again in October 1995, with the production of 211 tons of U_3O_8 (2).

The action of the former company NUCLEBRAS in the development of mining research for ores containing uranium, was of great importance for the discovery in Brazil of important deposits of natural occurrences of uranium deposits. Although there are currently other sites

for deposits of uranium ores discovered in Brazil, for historical reasons, we will highlight the main uranium occurrences discovered by NUCLEBRAS in the national territory.

-1- Deposit of Lagoa Real (Bahia)

The uranium anomalies of the uranium Province of Lagoa Real, in the Caetité municipality of Bahia, are found in an archaic basement of the zone composed of cataclastic granitoids, gneisses augens, gneisses microcline, granodiorites and albitites. Discovered in 1977, the uranium occurrence in Lagoa Real had reserves of 100,000 tons of uranium concentrate. Initially, the anomalies of Minas Cachoeira and Quebradas were explored, which together produced 300 tons of uranium annually by open pit mining (2).

Currently, uranium mining in Brazil is carried out by NIB at its Uranium Concentration Unit, located in the municipality of Caetité (Bahia). Activities include mining and mineral processing operations. The unit is located in the uranium province of Lagoa Real, where there is a resource of 99.1 thousand tons of uranium contained (U_3O_8) distributed in 17 deposits. The ore is extracted from the mine and transported by trucks to be crushed. After going through stages of primary and secondary crushing (particle size reduction operations), the material is disposed of in piles and receives a solution of sulfuric acid that extracts uranium from the rock. This process is known as leaching and it results in a liquid, uranium liquor - a solution of sulfuric acid with uranium. This uranium liquor is purified and treated with various chemical and physical separation processes, which generates the uranium concentrate, also known as yellowcake. This material is stored in special, fully sealed drums and proceeds to another stage of the nuclear fuel cycle: conversion (6). The Caetité Uranium Concentrate Unit started to be implemented in 1995, and the effective exploration of uranium was only started in 1999, on an experimental basis, when it already had all the necessary licenses to operate, having produced uranium concentrate commercially from the year 2000. This uranium reserve, known as Jazida da Cachoeira, was detected in 1977 in an area where there are about 100 thousand tons of ore (7).

-2- Deposit of Figueira (Paraná)

In the Figueira deposit, uranium mineralization is located in the sedimentary sequence between the coal seam and the limestone, associated with carbonaceous sandstones, siltstones. In sandstones, uranium mineralization is found in the form of uraninite between the interstices of quartz, grains cemented by a limestone cement. Within carbonaceous silts and coal, uranium

mineralization occurs in the form of organo-mineral complexes (2).

-3-Deposit of the Quadrilátero Ferrífero (Minas Gerais)

In the deposition of the Quadrilátero Ferrífero, the oligomitic metaconglomerates of the base section of the Moeda Formation have uranium mineralization, especially the horizons connected to a paleodrainage drainage in the direction of approximately $N45^\circ E$. The stones of the conglomerate are almost all quartz, rarely quartzite. It is a relatively immature conglomerate with an abundant matrix of light green quartz sericite, generally quite pyritic with uraninite and pitchblende mineralization (2).

-4-Amorinópolis Deposit (Goiás)

The Iporá-Amorinópolis area, where uranium mineralization occurs, is located in the so-called Amorinópolis horst. The area was subjected to tectonic movements of a tensile nature that caused gravity failures and injection of alkaline materials. The uranium mineralization of the Amorinópolis deposit is of two types, a primary with +4 valence uranium and a secondary with +6 valence uranium. The primary mineralization is composed of dark minerals, pitchblende (uraninite) and coffinite. The secondary consists mainly of autunite and sabugalite, which are products of alteration of primary mineralizations. Uranium mineralization is essentially controlled by the physical-chemical conditions of the host sandstone and by the hydrodynamic flow of the solutions (2).

-5-Itaia Deposit (Ceará)

The uranium mineralization of the Itaia deposit is associated with apatite or colophane. Typical apatite occurs in usually millimetric idiomorphic crystals, filling fractures and pores of feldspar rocks (episiênitos), gneisses, marbles and chalcosilicate rocks or even in gaps (2).

-6-Espinhares Deposit (Paraíba)

In the Espinhares deposit, uranium mineralization occurs in dams of feldspar rocks enclosed in gneisses in an area of about 1.2 km. It is related to metasomatic phenomena of the sodium type (albitization). Mineralized rock is composed of 80 to 90% feldspar, some biotites and small amounts of apatite and carbonates. Its grain size ranges from very thick pegmatite to microcrystalline. In the vicinity of the dikes, the surrounding rock (amphibolite biotite gneiss) is infiltrated by feldspar material. Several radioactive minerals, including uraninite, have been observed. The primary radioactive minerals

were mostly totally altered, forming secondary minerals not identifiable on the surface (2).

Since the initial studies carried out by the former NUCLEBRAS, NIB has been conducting several studies on the occurrence of uranium deposits in the Brazilian territory. It was observed that in Brazil, uranium occurs in different types of deposits and mineralizations: -1- marine platform sediments; -2- sedimentary deposits; -3- metamorphic sediments; -4- deposits of the karst type; -5- mineralization in granites; -6- uranium mineralizations in pegmatites; -7- metasomatic deposits (uranium in albitites); -8- mineralization in alkaline rocks and carbonatites; and -9- uranium lineaments and metallogenesis(1). As can be seen, Brazil has a high potential for uranium deposits. However, it is not enough to just explore the ores that contain uranium, but this must be done considering the sustainability indicators that are essential for carrying out the decommissioning.

3.2. Impacts caused by uranium exploration in Brazil

Decree No. 97,632, of April 10, 1989 (5), which provides for the regulation of Article 2, item VIII, of Law No. 6,938, of August 31, 1981, legislates on the issue of impacts caused by exploration of mineral resources in the Brazilian territory:

1st. The undertakings that are destined for the exploration of mineral resources must, when presenting the Environmental Impact Study - EIS and the Environmental Impact Report - EIR, submit to the approval of the competent environmental agency, a plan for the recovery of degraded area.

Single paragraph. For existing projects, a plan to recover the degraded area must be presented to the competent environmental agency, within 180 (one hundred and eighty) days, as from the date of publication of this Decree.

2nd. For the purposes of this Decree, processes resulting from damage to the environment are considered degradation, by which some of their properties are lost or reduced, such as the quality or productive capacity of environmental resources.

3rd. The recovery should aim to return the degraded site to a form of use, in accordance with a pre-established plan for land use, with a view to achieving environmental stability.

Regarding the exploration and processing activities of uranium ores, the CNEN-NE-4.01 (8) Standard has the following dictates: (1) Establishes the safety and radiological protection requirements of mining-industrial facilities that handle, process, as well as storing ores, raw

materials, steriles, residues, slag and tailings containing radionuclides from the natural series of uranium and thorium, simultaneously or separately, which can at any time during their operation or post-operational phase cause exposures undue exposure by individuals of the public and workers to ionizing radiation; (2) Applies to activities in mining-industrial facilities in operation, suspended or that have ceased their activities before the date of issue of this Standard, intended for mining, physical, chemical and metallurgical processing and the industrialization of raw materials and wastes containing associated radionuclides from the natural series of uranium and thorium, covering the stages of installation, operation and decommissioning of the installation.

It appears that both Decree No. 97.632 / 1989 and Norm CNEN-NE-4.01 require plans to recover degraded areas resulting from mineral exploration activities. Uranium exploration in Brazil began in 1982, in the municipality of Caldas (MG). In 1995, INB found that the unit's operation was economically unfeasible and ended its activities. Ten years later, the decontamination of its facilities and land began (9). The facilities, the soil, the waters and the equipment of the old mining are permanently monitored, as well as the radioactive materials that are stored there, in order to protect the environment and ensure the health of the workers of the unit and the residents of the region.

At the Caldas Decommissioning Unit, the Environmental Laboratory for Chemical and Radiological Analysis is installed, which carries out the necessary analyzes for monitoring the environment in areas where INB units in Bahia, Ceará, Minas Gerais and São Paulo operates. In 2012, IBAMA approved the Recovery Plan for Degraded Areas, which was prepared based on studies in the areas of hydrology, geochemistry, hydrochemistry and radioprotection, carried out with the objective of defining the works to be carried out and the actions of environmental recovery that must be developed in the unit (9).

Since its decommissioning in 1995, the Poços de Caldas Minerals Treatment Unit Complex has been the target of much criticism by parts of several entities, and mainly by the local population. Until the present date, no environmental recovery works have been carried out on the site where the mine operated. There is still a radioactive waste containment dam that has been in the open for decades. This dam has high amounts of radioactive waste from uranium, thorium and their descendants, as does radio. According to Pires (1), with regard to water resources, it is observed that mining causes important changes in the hydrological system. Such

changes, neglected environmentally, can lead to contamination of water courses and reservoirs. According to Pires (1), the exploration of the uranium mining activity necessarily requires high costs with the environment heading, costs that are not always available in the Union budget. It is a fundamental role of the State to provide essential services and we do not see uranium mining as a essential service. It is rather a means activity, in order to generate electricity, which, like any other that exploits natural resources, must receive sufficient investments to operate safely and undergo all types of inspection provided by law.

As a result of the Federal Public Ministry's action, the National Nuclear Energy Commission decided to institute an action plan for the regulatory control of the tailings dam of the Mineral Processing Unit of the Brazilian Nuclear Industries (NIB), located in the municipality of Caldas, in Minas Gerais. The full document was published in the Federal Official Gazette on 05/23/2019 (10). The President of the National Nuclear Energy Commission, in the use of the powers conferred on him by article 15, items I and V, of Annex I, to Decree n° 8.886, published in the Official Gazette of October 25, 2016, resolves:

Art. 1st To institute the Action Plan related to the regulatory control over the Tailings Dam of the Mineral Treatment Unit of the Nuclear Industries of Brazil - INB in the municipality of Caldas - MG, according to Annex I to this Ordinance;

Art. 2 Attribute to the Directorate of Radioprotection and Nuclear Safety of CNEN the execution of the referred Plan;

(...)

ANNEX I

Directorate of Radioprotection and Nuclear Safety

Action plan

Regulatory control actions on the tailings dam of the Mineral Processing Unit (MPU) in Caldas

Introduction

This Action Plan aims to establish the set of actions and milestones within the regulatory scope that will guide the conduct of licensing, inspection and control activities of the tailings dam of the Mineral Processing Unit (UTM) in Caldas, owned and operated, under the responsibility of Nuclear Industries of Brazil - INB.

This Plan was prepared based on the actions recommended by the Federal Public Ministry, through the Federal Attorney's Office in the Municipality of Pouso

Alegre. The deadlines were established taking into account a feasible timetable for compliance.

Actions and Deadlines

I. CNEN shall, within 360 (sixty) days, within its sphere of competence, update the regulations relating to the Safety of Tailings Dam Systems containing Radionuclides, in order to adapt it to the National Policy on Dam Safety (PNSB) provided for in Law No. 12,334, of September 20, 2010.

The regulations must contain, at a minimum:

I - The registration system for dams inspected by CNEN, under construction, in operation and deactivated, as well as the periodicity of data update;

II - system of classification of tailings dams containing radionuclides, by risk category and by associated potential damage;

III - the establishment of minimum requirements for the implementation, by the entrepreneur, of a dam safety monitoring system, the level of complexity of which will depend on the classification of the structure by associated potential damage;

IV - the frequency, the qualification of the responsible team, the minimum content and the level of detail of the following inspections for Tailings Dams containing Radionuclides: (i) Regular Safety Inspection; (ii) Special Security Inspection; (iii) Periodic Dam Safety Review, in proportion to the dam's complexity and the needs to guarantee adequate safety conditions;

V - the qualification of the responsible team, the minimum content, the level of detail and periodicity of updating and revision of the Emergency Action Plan for Tailings Dams containing Radionuclides, proportionally to the complexity of the dam and the needs to guarantee adequate conditions of security;

VI - the requirement for the entrepreneur to submit to CNEN, at a periodicity to be fixed, a Declaration of the Stability Condition of the structure, to be mandatorily prepared by an external team, hired exclusively for this purpose;

VII - the requirement that the Safety Plan of every dam that is to be built after the enactment of Law No. 12,334 / 2010 has the "as built" project (as built);

VIII - the requirement that the Safety Plan of any dam that was built before the enactment of Law No. 12.334 / 2010 and that does not have the "as built" project (as built), contains the "as is" project (as it is), within a period to be fixed in the regulations.

IX - the establishment of deadlines, requirements and conditions for the decommissioning of nuclear mining dams that are in an abandoned situation, deactivated or with no expected return from operations;

X - the definition of the nominal value considered minimum for the Safety Factor of the dams, in compliance with the best national and international practices.

2. NNEC shall, within 90 (ninety) days, collect data on all tailings dams subject to its supervisory power, pursuant to art. 5 of Law 12.334 / 2010. The survey referred to in the caput must comprise, at least:

I - the identification of the entrepreneur;

II - identification of the person responsible for the design and execution of the construction;

III - identification of the existence of a "as built" or "as is" project, as appropriate.

3. NNEC shall, within 60 days, adopt all necessary measures so that the identified structures are registered in the National Dam Safety Information System (SNISB), established by Law 12.334 / 2010, if they have not yet been included by the entrepreneur.

4. NNEC shall adopt, within 180 days, the necessary measures to increase the inspection activities of the dams, either by requesting the assignment of servers from other bodies, entering into agreements or cooperation agreements, or even the emergency hiring of private agents. specialized.

5. Regarding specifically the UTM-Caldas Tailings Dam, NNEC must present a conclusive opinion, considering DNPM Ordinance No. 70.389 / 17, on the Emergency Action Plan submitted by NIB to MPF, within 45 days, from receipt of the document by NNEC, as well as verifying the effective implementation of the PSB, especially the PAEMB, by INB, monitoring the execution of the plans within 06 months, from the receipt of the complete PSB, when it will then report to the MPF, informing compliance or not by the company.

6. NNEC must monitor the measures to be implemented by NIB related to the restructuring of the tailings dam monitoring system, concurrently with the deadlines given to INB, analyzing the projects in a timely manner (before the respective execution), as well as monitoring the execution of the work.

The non-observances of the environmental legislation result from the lack of transparency and the fact that the State itself, through NNEC and IBAMA, inspecting itself, that is, inspecting the state-owned companies INB and Eletrobrás. In this context, the monopoly on activities

involving uranium has been discussed in Congress (JORGE, 2014). As a result, Jorge (2014) suggests the creation of a Nuclear Energy regulatory agency, since NNEC cannot regulate itself, nor legislate in its own cause.

The exploitation of uranium carried out by the Minerals Treatment Unit in Poços de Caldas left a great heritage of environmental liability of social responsibility of INB. The MTU Complex is formed by the Osamu Utsumi mine, in "open skies", with a "lake" of radioactive acid effluents from acid mine drainage (DAM). In December 2004, NIB signed a term of reference for the preparation and presentation of the closure plan requested jointly by IBAMA and NNEC. Several studies have been carried out to support the preparation of the closure plan. Since then, INB has, as its main liability, for closure purposes, the acid drainage generated in the pit ("lake"), in the waste dumps and on the tailings beach (11).

Acid mine drainage (DAM) at Osamu Utsumi Mine is relevant, both from an environmental point of view, and for the costs involved in neutralizing it. DAM is caused, basically, by the natural oxidation of metal sulfides (exposed in the pit, waste dump and tailings dam) in the presence of water and oxygen. As a result, there is formation of sulfuric acid, reduction of pH and dissolution of heavy metals associated with rocky matrices with serious environmental impacts. However, the water courses close to the mine pit, and used for public supply, showed high concentrations of natural radionuclides, mainly uranium-238 (238U) and radio-226 (226Ra) (11).

Currently, legal procedures for remediation of the site and decommissioning of this area are in progress, and NIB must comply with the requirements and standards established by the National Nuclear Energy Commission and the Brazilian Environment Institute (IBAMA). Figure 1 shows the spatial view of the Osamu Utsumi Mine in Poços de Caldas, with the mine pit ("lake"), with the environmental liabilities generated by the mineral exploration of uranium.



Fig.1: Spatial view of the Osamu Utsumi Mine in Poços de Caldas.

Source: Google (2020).

After the deactivation of the Osamu Utsumi Mine in Poços de Caldas, INB started to explore uranium in Lagoa Real, in the municipality of Caetité, in Bahia. Currently, the Lagoa Real Uranífera Province is the most important occurrence of uranium currently in Brazilian territory. Figure 2 shows the spatial view of the Lagoa Real Mine. According to Chaves (2005), the area is inserted in the so-called quadrilateral formed by the cities of Caetité, Lagoa Real, Maniaçu, and São Timóteo, near the border with Minas Gerais. After its discovery, several works were carried out with a view to mapping the bodies mineralized in uranium and its enclosures, characterizing its structural framework, dating and understanding the genesis of uranium mineralization and its spatial distribution. Chaves (12) also clarified that:

Mineral paragenesis and the distribution of uranium mineralization and its formation conditions make Lagoa Real Province an example of economic uranium concentration, occurring primarily in the form of oxide (U_3O_8), constituting the mineral ore called uraninite present in metamorphic rocks medium to high degree, associated with sodium metasomatism.



Fig.2: Spatial view of the Lagoa Real Mine in Bahia.

Source: BBC News (2020).

Porto et al. (13) presented a study on the impacts caused by uranium mining in Lagoa Real. These authors made some considerations in relation to the damage caused to the natural environment and to people:

Mineral exploration activities, in general, are known for the various impacts produced, such as: generation of effluents and toxic waste; environmental contamination of soil, air and water resources; occupational exposure to toxic substances (cyanide, sulfuric acid, etc.), among others. However, the specific case of uranium exploration has a complicating element, radioactivity. And there are many uncertainties that nurture controversies among scientists, researchers and opinion makers in the debate about the future biological

effects due to human exposure to radioactive materials, especially exposures to low doses.

Regarding the health risks and impacts of the communities that inhabit the region surrounding uranium mines, there is a lack of scientific studies. Uranium mining in Caetité has been marked by many controversies. There are several reports of administrative irregularities, operational problems, accidents at work, leaks of radioactive material into the environment and signs of environmental contamination of groundwater. Local civil society has manifested itself since the mine's first years of operation with regard to possible risks and impacts to health and the environment.

The main environmental problems and risks arising from uranium mining and processing activities in Caetité, based on reports from representatives of local social movements and people who live in the vicinity of the mine, are: (1) air pollution from rock detonations for extraction of the ore, with the release of radioactive dust, radon, and other radiotoxic substances; (2) suspicions of groundwater contamination, quite possibly as a result of the various spills of radioactive material from the basins and waste containment tanks to the environment; (3) excessive water consumption in a region where this resource is scarce; (4) the lack of transparency regarding NIB's environmental management practices; (5) withholding information and disinformation regarding the potential risks and impacts associated with uranium mining activities.

Currently, the Federal Government is studying the possibility of exploring the Itataia uranium mine, in Santa Quitéria, Ceará (Figures 3 and 4). The Santa Quitéria Consortium is a partnership between INB and Galvani, a company that produces phosphate fertilizers, for the implementation of a joint mining project. The purpose of the partnership is to explore uranium and phosphate, found in an associated way in the Itataia deposit, located in the municipality of Santa Quitéria (Ceará). Phosphate is predominant, with reserves of 8.9 million tons. The uranium reserves are 80 thousand tons (14). The forecast is that 240,000 tons of phosphate and 1,600 tons of uranium concentrate are produced annually by the Consórcio Santa Quitéria. The ore, after being extracted from the deposit, will undergo a process of separation of elements. The phosphate will remain with Galvani, which will use it in the manufacture of fertilizers and animal feed, and the uranium will be delivered to NIB for the production of the uranium concentrate. INB owns the mining rights to the deposit, located in the domains of Fazenda Itataia, which has 4,042 hectares. The operation of the Santa Quitéria Consortium will quadruple the production of uranium

concentrate, used by NIB in the production of nuclear fuel, and will increase Brazilian production of phosphate fertilizers by 10%. The mine is expected to generate around 800 direct jobs and contribute to the development of the region (14).

The Itataia uranium deposit is located in the central part of the State of Ceará, about 45 km southeast of the city of Santa Quitéria. It is the largest uranium reserve in the country and its economic viability is dependent on the exploration of the associated phosphate (15). This means that the extraction of uranium is conditioned to the production of phosphoric acid, which is the input used in the production of fertilizers. Thus, it is necessary to analyze the benefits, costs and damages, mainly for the population in the immediate vicinity of the mine, formed by about six thousand families, distributed in twenty-seven communities in the municipality of Santa Quitéria and fifteen in the municipality of Itatira(15).



Fig.3: Main entrance to the Itataia mine.

Source: Diário do Nordeste (2020).

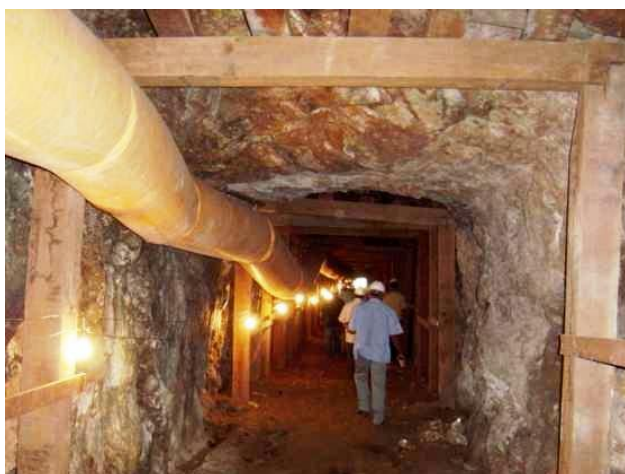


Fig.4: Interior of the Itataia mine.

Source: The voice of Santa Quitéria (2020).

However, for uranium ores to be exploited in Itataia, licensing by IBAMA is required. A report from the newspaper O POVO, in February 2019, showed that IBAMA denied the license for the mine to operate:

IBAMA considers that the installation of a uranium and phosphate extraction plant in Ceará is not feasible for the environment. In the wake of the Brumadinho (MG) tragedy, the Environment and Renewable Resources Institute (IBAMA) decided to discard the environmental licensing process for the Santa Quitéria / Itataia uranium plant in Ceará. According to an e-mail sent to O POVO by the agency's communications department, the "phosphate and uranium mining project was shelved due to the environmental infeasibility of the study presented".

The newspaper O POVO had requested information from the national superintendence of IBAMA about the result of the analysis of the Environmental Impact Study and the licensing of the enterprise that would benefit radioactive material. Since 2014, environmentalists opposed to the implantation of the plant and the Consórcio Santa Quitéria, formed by mining company Galvani and Indústrias Nucleares do Brasil, awaited the decision of the licensing agency.

One of the points most criticized by environmentalists and communities that would be impacted by the plant is the construction of the dam for the disposal of waste. According to data from the Santa Quitéria Consortium, the projection is that the uranium waste would reach 90 meters in height. Phosphogypsum (deposit of phosphoric acid production) would reach 70 meters in height.

According to data from process 02001.005454 / 2004-24 / IBAMA, the Sertão Ceará plant would annually produce 1,600 tons of uranium concentrate and 1,050,000 tons of phosphate derivatives.

In 2014, the Center for Work, Environment and Health at the Federal University of Ceará (Tramas-UFC) filed for representation at the Federal Public Ministry asking for the annulment of the EIA-Rima presented by the companies. And it filed with Ibama civil society demonstrations against the enterprise. According to Tramas-UFC lawyer Talita Furtado Montezuma, several irregularities were pointed out to the two federal agencies. IBAMA even issued a provisional technical opinion and asked for complementations to the environmental study.

In August last year, there were meetings between IBAMA and the entrepreneurs in Fortaleza and the last opinion of the agency pointed to the lack of water viability of the project, which intended to consume, with the plant,

911 m³ of new water per hour. Entrepreneurs even asked for a review of the opinion.

IBAMA has not yet detailed what it called the filing of the lawsuit due to the "environmental infeasibility of the study presented" by Consórcio Santa Quitéria. However, he ended up agreeing with points of the representation that point, for example, to the "lack of data on radiation" in the management of uranium, "undersizing risks", "lack of effectiveness of mitigating measures", "absence of communities in the social diagnosis" and the "lack of computer simulation on the dispersion of radioactive pollutants".

The extraction of uranium and phosphate from the Santa Quitéria Plant, in Ceará, according to the project, would be used to manufacture fertilizers, fertilizers and other chemical products. 92.6 million reais is the estimated ICMS and ISS collection for Ceará with the uranium plant. In November 2015, the expectation of the president of Indústrias Nucleares do Brasil, Aquilino Senra, was that the previous license from IBAMA would be issued and would allow the operation of the Santa Quitéria Plant in 2019. The phosphate production would be for Ceará, Piauí, Tocantins, Maranhão and Bahia.

One of the concerns of residents of Santa Quitéria and surrounding municipalities is that the dam contaminates the Quixadá weir with radioactive material.

A report by Samuel Quintela published in Diário do Nordeste in October 2019, shows the disadvantages in relation to the opening of the Itataia mine:

After changes in the direction of Ibama, a project that will have an investment of US \$ 350 million may be resumed. Operations are expected to begin by 2025, but experts point to a risk of contamination by radioactivity. Previously impossible for environmental reasons, the Itataia uranium and phosphate mine, in Santa Quitéria, already has new plans for the start of extraction operations.

The potential of the new venture is already beginning to be compared with the impact generated by Companhia Siderúrgica do Pecém, considering the economic activity of the region. However, the enterprise's socio-environmental viability is questioned because of the environmental risks of the business.

The exploration project for the Itataia deposit was initially prepared in 2009 by the Santa Quitéria Consortium. The partnership is formed by Galvani (a private company) and the state-owned Indústrias Nucleares do Brasil (NIB). However, the business ended up being left

out after companies failed to obtain an environmental license for the exploration of the deposit.

Although NIB states that advances in mining techniques facilitate the application of the project, the plant would probably need a tailings dam. Despite the similarity of Vale's cases in Brumadinho and Mariana, where the dams broke, left victims and affected the environment, the state company claims that there would be no risks in Santa Quitéria.

There are risks of contamination of soil and water resources in the region. Over the years, just by checking feasibility, the part of the soil in the region around the Santa Quitéria deposit would already have uranium levels above normal. The mine exploration process, which will be based on the dynamization of rocks, may dispense dust with radioactive elements that could damage the health of the region's residents, increasing the incidence of various types of cancer, such as lung cancer.

During the twenty years of exploration, a larger volume of tailings would be generated than that of the dam in Mariana, but a rupture can cause a greater impact than there, due to the concentration of radioactive minerals. The Capital would not be free of contamination risks, in case of carelessness, since the material would be drained by CE-020 and would be sent to INB through the Port of Mucuripe. Therefore, the Santa Quitéria exploration project does not offer socioeconomic viability.

3.3. Criticisms of CNEN's inspection

Uranium exploration is an important activity for the development of Brazil, but it must be carried out respecting people's health and the natural environment. It is not enough to have a set of laws and regulations that are ingeniously written, but that work properly in practice. It is observed that, although CNEN has uranium mining management standards, whose dictates legislate from mining exploration procedures to decommissioning, its inspection in this type of undertaking is very precarious. Thus, it is important to analyze the discussion by Porto et al. (2014) on NNEC's performance in the inspection of uranium mining in the national territory:

NIB owns about 99.99% of its shares under the control of the National Nuclear Energy Commission (NNEC), which, in turn, is linked to the Ministry of Science, Technology and Innovation, and aims to plan, establish standards, inspect, license and control the activities of the nuclear sector in the country. Thus, it is observed that Brazil does not comply with article 8 of the International Nuclear Safety Convention, according to which the bodies charged with the promotion of nuclear

energy must be separated from those that carry out regulation and inspection activities.

For Brazil to be efficient in the inspection of uranium mining, it is necessary that all laws of radiological protection of people and the natural environment are respected. Therefore, it is necessary for NNEC to stop inspecting and regulating itself. This thesis is highly defended by Jorge (16). According to this author, nuclear power generation needs a regulatory agency.

The environmental liability left by uranium mining is huge, not only at the site of exploration, but also in the surrounding areas, especially in the water resources used by the population. An interesting report by André Borges in Exame Magazine (17), shows the precarious inspection of NNEC in the activities of the Lagoa Real Mine:

The Brazilian Institute of Environment and Renewable Natural Resources (Ibama) received explanations from Nuclear Industries of Brazil (NIB) about the case of uranium contamination in a well in the municipality of Lagoa Real, in southwest Bahia. The environmental agency, the only one responsible for the licensing of radioactive material in the country, should soon take a position on the case, which could result in a fine to INB for omitting information.

NIB was immediately notified by Ibama last Saturday, based on a report published by the State. The state-owned company, which has a monopoly on the exploitation of radioactive material in the country, found contaminated water with high uranium content in the well of a farm in the rural area of Lagoa Real, but did not inform Ibama, the federal government or even the government of Bahia. The first inspection, carried out by the company in October 2014, identified a quantity of the toxic ore more than four times above the limit allowed for human consumption.

None of this, however, was communicated to Organs responsible bodies, nor to the city hall. A second check was carried out by NIB in March of this year, and the company again found a uranium index more than three times above that allowed by health agencies. Again, however, there was no communication on the case. The two bulletins did not reach the city hall of Lagoa Real until the end of May, as the State revealed.

It was when the municipal management tried to go to the owner of the contaminated well and inform him that he should no longer consume that water. Still, nothing came to the attention of the federal governments and the State of Bahia. Around the contaminated well site, dozens of other properties with exactly the same wells were not

alerted to the problem and continued to use their wells regularly. "Immediately after being informed by the report, Ibama notified NIB, NNEC (National Nuclear Energy Commission) and the competent health authorities to adopt the necessary measures so that there is no risk to the local population," said Ibama in a note.

The government of Bahia, with support from Ibama agents, reported that, based on the complaint, it set up a task force in the region to collect water from all wells and check the quality of the water consumed by the local population. The rules for the environmental licensing of the uranium mine, which is located in the neighboring municipality of Caetité, require that INB forward periodic reports on the implementation of environmental programs to Ibama and, "in the event of an unusual event that may result in damage to the environment and risk to the population, immediately report the incident to Ibama, NNEC and the Bahia Environment and Water Resources Institute (EWRI).

"The eventual omission by INB characterizes noncompliance with condition 1.4 of the Caetité mine operating license, a fact that, if confirmed, will result in the imposition of a fine," informed Ibama. Rule 1.4 mentioned by the institute is part of the "general conditions" required by Ibama, so that the company can operate in the exploration of uranium. The item states that "Ibama, NNEC and ERC (Environmental Resource Center) must be notified immediately in the event of any accident that causes an environmental impact or any unusual event that may cause potential damage to the environment."

Despite the requirement, NIB claims that it did the well owner in Lagoa Real a favor and that it is located in an area outside its responsibility. The state company also says that the contamination has nothing to do with its activities in the region, which have been operating for 15 years, because it is 20 kilometers away and is part of another hydrographic sub-basin. Ibama has already assessed NIB on another occasion. In November 2009, the state company was fined R\$ 1 million for failing to comply with the environmental licensing condition that determines the immediate report to the agency of any accident that occurred in the enterprise.

On October 28 of that year, it was found that there was a leak of organic solvent with uranium. The Institute notified the company to submit a detailed report on this accident. The inspection of the area where the accident occurred was carried out on November 18, when Ibama technicians visited some points inside the project where the leak was detected.

The team found the leakage of the organic solvent containing uranium, which overflowed from the processing tanks to the crushed box of the processing unit. Due to the heavy rain, this material also overflowed into the rainwater drainage system, reaching the drainage channel, which directs the water to the Córrego do Engenho Dam. The result was the contamination of 15 cubic meters of material (earth and gravel), removed from the gravel box, and 33 cubic meters of contaminated soil from the drainage channel.

The National Nuclear Energy Commission (NNEC) informed O POVO that the Santa Quitéria Consortium, until today, had not sent enough documentation to release the operation.

When evaluating the performance of the National Nuclear Energy Commission (NNEC) in the exploration of uranium mines in Brazil, specifically analyzing the cases of the Poços de Caldas and Caetité mine, there was a lack of supervision by this body when dealing with the exploration and exploration processes. decommissioning. This puts NNEC's performance in check if the Itataia mine is to be exploited one day, as previous experiences have shown poor inspection by NIB. Possibly alerted of the inefficiency of NNEC's inspection with the INB, many civil entities mobilized to prevent the Itataia uranium mine from functioning.

In 2006, the Environment and Sustainable Development Commission of the Chamber of Deputies presented the report of the nuclear safety and inspection working group, whose rapporteur was Deputy Edson Duarte (18). In this document, in addition to other issues analyzed within the Brazilian Nuclear Program, NNEC's role as a regulator and supervisor of itself (18) was called into question:

It is no longer today that Brazilian society, especially through renowned members of the scientific community, has been questioning the independence and transparency of the inspection carried out by NNEC over the nuclear sector. Still in the 70s, the Brazilian Physics Society (SBF), after exhaustive studies of the Brazilian Nuclear Program, suggested that NNEC be split into two distinct entities - one that regulates, licenses and supervises the use of nuclear energy, and another, which manages of the Brazilian Nuclear Program. The claim was that it would be technically, politically and ethically incorrect for NNEC to self-monitor itself in various activities attributed to it within the scope of the nuclear program.

In 1985, the then President of the Republic, José Sarney, established, through Presidential Decree No.

91.606 of 02/09/85, the formation of a "Commission for the evaluation of the Brazilian nuclear program", under the presidency of the scientist José Israel Vargas (Minister of Science and Technology during the term of President Itamar Franco and held in office during the first term of President Fernando Henrique Cardoso). Formed by academics in the scientific field, engineers, economists, administrators and entrepreneurs, the commission aimed to produce recommendations for public administration action in the field of nuclear technology. Among the recommendations presented by what became known as the "Vargas Report", we highlight:

- Create, within the ambit of the Presidency of the Republic, the National Commission for Radioprotection and Nuclear Safety, which would be in charge of the normative, licensing and inspection functions exercised by NNEC, whose President would be appointed by the President of the Republic, with the approval of the Federal Senate, and with mandate not coinciding with those of the executive branch leaders;
- Create the National Nuclear Research and Development Commission, in the form of a foundation under the Ministry of Mines and Energy, which would assume the research and development activities under the responsibility of NNEC. This Commission would be chaired by a Deliberative Council composed of representatives from the Ministry of Science and Technology, Eletrobrás, Nuclebrás (currently NIB), and personalities from the technical and scientific community, appointed by the President of the Republic, following a proposal by the Minister of Mines and Energy;
- Assign the coordination of basic nuclear research activities to the Ministry of Science and Technology.

However, taking a historical overview of the Brazilian nuclear issue, the 2006 nuclear safety and inspection working group's report investigated opinions contrary to the NNEC division. Some reports of the time presented considerations by the authorities for not complying with the recommendations made by the Vargas Report, such as (18):

Paulo Richter - Secretary-General of the Ministry of Mines and Energy - *Jornal do Brasil*, 11/15/1986:

(...)

"The non-separation of NNEC is a solution that can be carried out immediately and less costly (...), however this separation is necessary at a later stage".

(...)

Rex Nazaré Alves - President of NNEC in 1986 - *The State of São Paulo* 11/06/1986:

(...)

“NNEC should not be divided now so that there is no dispersion of financial and technical resources in two other autonomous and independent bodies, since the parallel Nuclear Program is essential for the country, and this is going very well, after all, in a team that is winning doesn't move ”.

(...)

The answers to these arguments were already in the Vargas Report. But the reality would manifest itself more sharply exactly one year later, and in the worst possible way, with the Goiânia tragedy. According to the 2006 nuclear safety and inspection working group report (pages 46 and 47):

As in other countries, the National Nuclear Energy Commission was created with the dual purpose of promoting the use of nuclear energy and supervising its use, to ensure that it was used without risk to the population. This was the type of sectoral organization that predominated in the middle of the last century. Right after World War II, the main concern about the nuclear issue was related to National Defense. For this reason, several countries have adopted strict state control and a major centralization of nuclear activities. It should be noted that it was this centralization of nuclear activities that enabled the existence of a classified nuclear program in Brazil, with the objective of producing nuclear artifacts for military purposes.

Nowadays, however, the world's attention is more directed towards the safety of populations and the environment. Especially for the case of Brazil, the option for the exclusively peaceful use of nuclear energy was enshrined in its Constitution. In the United States, the risks arising from having an institution regulating the same activity that it helps to operate and develop led the country to review the sectoral legislation. The Atomic Energy Commission (AEC) was extinguished, which, like NNEC in Brazil, centralized most of the activities in the nuclear area, and the Nuclear Regulatory Commission - NRC (Nuclear Regulatory Commission) was created, as an independent regulatory agency. The operational and sectoral policy responsibilities of the former Atomic Energy Commission have been transferred to the Department of Energy. Similar cases were observed in Argentina, Spain, Canada and France, among others, as pointed out in a study by the Legislative Consultancy of the Chamber of Deputies.

In the report of the 2006 nuclear inspection and safety working group (p. 46) there is a mention of Rex Nazaré Alves:

Rex Nazareth was a collaborator of the military dictatorship, acting as administrator of the parallel nuclear program. He was responsible for the secret accounts, dubbed "delta", which were intended to finance the national war program - the construction of the bomb. The select group that took care of the "delta" also had Admiral Othon Pinheiro, now president of Eletronuclear. Rex Nazareth remains in the government today, as a "civil society representative" on the NNEC deliberative committee.

Legally, it cannot be admitted in the current Brazilian Nuclear Program that an institution like NNEC continues to operate within the framework established by military influence, whose purpose was the construction of the Brazilian atomic bomb. Currently, the scenario requires the expansion of protection to the environment and people, against the harmful effects caused by radiation. Thus, an institution like NNEC that regulates and supervises itself, has no more space within the current scientific scenario of the Brazilian Nuclear Program.

IV. CONCLUSION

At the beginning of the Nuclear Program, uranium exploration in Brazil was carried out by foreign technology, with the United States having almost absolute dominance in this activity.

The creation of the National Research Council was an important milestone for Brazil to master the technology for the exploration and processing of uranium.

The creation of NUCLEBRAS marked the growing effort of the uranium exploration program in Brazil.

With the creation of the National Nuclear Energy Commission (NNEC), CNPQ is no longer responsible for the exploration and processing of uranium.

Brazil has large uranium reserves in its territory, but due to the lack of public policies for the sector, exploration still suffers from the lack of feasibility throughout the national territory. Uranium exploration should be a state policy, not a government policy.

The monopoly of uranium exploration in Brazil is carried out exclusively by the state-owned Nuclear Industries of Brazil (NIB), which succeeded NUCLEBRÁS. NNEC is a majority shareholder of NIB, where it holds almost 100% of its shares.

The Osamu Utsumi uranium mine located in the Poços de Caldas deposit, in Minas Gerais, was the first to start operating in Brazil. After decades of operation, mine exploration has left an incalculable environmental liability. Currently, NNEC and IBAMA are studying a site recovery plan.

After the deactivation of the Osamu Utsumi mine, the Caetité Uranium Concentrate Unit was implemented in 1995, and is still operational today, despite several reports of contamination in the areas adjacent to the mine. The exploitation of uranium in Caetité, as happened in the case of the Osamu Utsumi mine, is generating a great environmental liability.

NIB has been seeking environmental licensing to explore the Santa Quitéria uranium mine in Itaia, but for operational reasons, and also due to the various complaints made by civil society, IBAMA has not authorized its operation.

NNEC cannot currently operate within the dictates that were established during its creation, when it received strong influences from the military that aimed to create an institution with the purpose of developing nuclear technology for military purposes.

Since NNEC is a majority shareholder of NIB, it should neither regulate nor supervise uranium exploration activities in Brazilian territory, since, in doing so, NNEC regulates and inspects itself, which is legally incorrect.

NNEC's inspection of the activities carried out by INB proved to be quite inefficient. It is necessary to create a Nuclear Energy Regulatory Agency in Brazil.

It is necessary to create laws that are rigorous in the establishment of new guidelines aimed at improving the technology of uranium exploration in Brazil, having as main theme the radiological protection of the natural environment and people.

NNEC's management in the exploration of uranium ores by administrative normative acts proved to be inefficient as a power of law in the inspection of NIB.

The inefficiency of NNEC's inspection was clearly shown when, by the action of the Federal Public Ministry, it was forced to build an action plan for the regulatory control of the tailings dam of the Mineral Processing Unit (UTM) of the Nuclear Industries of Brazil (NIB), located in the municipality of Caldas, in Minas Gerais.

The exploitation of uranium mines and their decommissioning procedures should be strictly discussed as a law by the National Congress that really has the power to draft laws on Brazilian nuclear policy.

It is necessary to create, within the Environmental Law, the Brazilian Nuclear Law that must contemplate the stages of the exploration and decommissioning of uranium mines existing in the national territory.

Brazilian Nuclear Law must contemplate the participation of society in debates on the exploration and operation of uranium mines.

Brazilian Nuclear Law must contemplate the possibility of popular action in the event of abnormalities in the operation of uranium mines.

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