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Uranium Mine Remediation Challenges in Brazil

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Brazilian Nuclear Energy Commission (CNEN)
BRAZIL

Population: 197,755,800
Area: 8,514,215 km²
6th economy in the world
7th Uranium reserves

Electricity sector

Installed capacity: 100 GW
Hydro: 74%
Oil, gas and others: 23%
Nuclear: 3%
Nuclear Sector in Brazil

PRESIDENCY OF THE REPUBLIC

MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION
- Brazilian Nuclear Energy Commission (CNEN)

MINISTRY OF ENVIRONMENT
- Brazilian Institute for Environment (IBAMA)

MINISTRY OF MINES AND ENERGY
- Eletrobras Companies (ELETROBRAS)

MINISTRY OF DEFENSE
- The Navy Technological Center (CTMSP)

MINISTRY OF FOREIGN AFFAIRS

OTHERS MINISTRIES
- MINISTRY OF EDUCATION
- UNIVERSITIES

Eletrobrás Termonuclear S.A. (ELETRONUCLEAR)

NPP´s ANGRA 1,2,3
THE BRAZILIAN NUCLEAR POLICY

The Constitution of 1988 of the Federal Republic of Brazil states that the Union has the exclusive competence for managing and handling of all nuclear energy activities, including the operation of nuclear power plants.

The Union holds the monopoly of the survey, mining, milling, exploitation and exploration of nuclear minerals, as well as of the activities related to industrialization and commerce of nuclear minerals and materials.

The Union is also responsible for the final disposal of radioactive waste. All of these activities shall be solely carried out for peaceful uses and under the approval of the National Congress (Brazilian Constitution).
THE BRAZILIAN NUCLEAR POLICY

Brazil has established and maintained the necessary legislative and regulatory framework to ensure the safety of its nuclear installations, including irradiated fuel, radioactive waste management and transport of radioactive materials.

The constitutional principles regarding protection of the environment also require that any installation which may cause significant environmental impact shall be subject to environmental impact studies that shall be made public.
Nuclear Installation (Brazil)

Definition:

Installation in which nuclear material is produced, processed, reprocessed, used, handled and stored in substantial quantities, to CNEN’s judgment, such as:

Nuclear Power Plants, Research Reactors, Uranium and/or Thorium Mining and Milling Facilities, Enrichment Plants, Fuel Fabrication Facilities.
Brazilian Nuclear Energy Commission
CNEN

✓ CNEN was created in 1956 (Decree 40110 of 10/10/1956) to be in charge of all nuclear activities in Brazil.

✓ CNEN is the Brazilian Nuclear Regulatory Body responsible for the Licensing and Control of:
  – Nuclear power plants;
  – Nuclear fuel cycle, including Uranium mining and milling;
  – Research reactors;
  – Medical, industrial and research installations;
  – Radioactive waste management;
  – Transport of radioactive materials.
CNEN Staff

2200 employees

- 49% university level
- 12% Ph.D
- 17% master of science
- 16% specialization
- 4% undergraduate

- 51% intermediate level
THE LICENSING PROCESS (NUCLEAR)

The licensing regulation establishes:

- That **no nuclear installation shall operate without a license**;

- The necessary **review and assessment** process including the specification of the documentation to be presented to CNEN at each phase of the licensing process;

- A system of **regulatory inspections** and the corresponding enforcement mechanisms that include the authority of CNEN to modify, suspend or revoke the license.
THE LICENSING PROCESS (NUCLEAR)

The licensing process is divided in several steps:

- Site Approval - (Site Report);
- Construction License - Preliminary Safety Analysis Report (PSAR);
- Authorization for Nuclear Material Utilization – (Safeguards) ;
- Authorization for Initial Operation - Final Safety Analysis Report (FSAR);
- Authorization for Permanent Operation;
- Authorization for Decommissioning.
Mining and Processing of ores containing U and/or Th

- Borborema (RN/PB) - pegmatitos
- Bunge Fertilizantes - Araxá (MG)
- Cambuí (carvão) - Figueira (PR)
- Cia. Ind. Fluminense - Clí - S.J.Rey (MG)
- CBL - Araçuaí (MG)
- CBMM - Araxá (MG)
- Extrativa Manganês - S.J.Rey (MG)
- Fosfértil - Tapira (MG)
- MIBRA - Nazareno (MG)
- Millennium - Mataraca (PB)
- Min. Catalão - Catalão (GO)
- Min. Mamoré - P. do Bom Jesus (SP) e S. Tiago (MG)
- Min. Taboca - Pitinga (AM)
- Min. Serra do Sossego (PA) - CVRD
- Projeto 118 (PA) - CVRD
- Ultrafértil - Cubatão (SP)
Mining and Processing Facilities in Brazil

**Today - Caetité**
Mining and processing facility *in operation* since 2000 with reserves of 100,000 t of $\text{U}_3\text{O}_8$, and a production capacity of 400 t/year of yellow cake.

**Future - Santa Quitéria**
The largest discovered uranium reserve in Brazil (estimated 142.2 thousand tonnes of uranium inter-mixed with phosphates)
Mining and Processing Facilities in Brazil

Past – The first uranium mining and processing facility of Brazil, CIPC, located at the Poços de Caldas plateau, in the state of Minas Gerais –

- U was produced to supply the domestic demand (2 PWR-type reactors);
- The installation was operated by state-owned company – The Brazilian Nuclear Industries (INB);
- Uranium was mined by open pit and the extraction process was sulfuric acid leaching.
Poços de Caldas Mining and Processing Facilities

September, 1948 - Radioactivity detected in the site;

October, 1952 - Beginning of the Uranium Research;

1st semester, 1977 - End of the Uranium Research;

May, 1982 - Beginning of operations;

December, 1995 - End of production;

Total Production - 1.200 t de $\text{U}_3\text{O}_8$

“Low” Grade Uranium Deposit: 675 - 1705 ppm of uranium
Main Characteristics:

- Located close to important tourist cities between 2 major drainage basins (Antas & Verde rivers);
- The water is used for irrigation and cattle watering.
Licensing Process (Brazil)

**Nuclear Installation** - Nuclear Fuel Cycle Installations (including Mine and Processing of Uranium)

Nuclear installations are subject to both:

1 - A **Nuclear License**, by CNEN; and  

(Ministry of **Science, Technology and Innovation**)

2 – An **Environmental License**, by the Brazilian Institute for the Environment and Renewable Natural Resources – IBAMA, with the participation of state and local environmental agencies.

( Ministry of **Environment** )
Licensing Process

POÇOS DE CALDAS MINING AND PROCESSING FACILITIES

✓ When the nuclear licensing process took place in the late 70’s - early 80’s, no planning was made for the decommissioning phase;

✓ Mining and Processing were developed before the establishment of the environmental legislation (1986);

✓ At that time, the Operator did not have the legal obligation of presenting an Environmental Impact Statement (EIS) prior the operation of the mining and processing facilities.

→ Legacy
POÇOS DE CALDAS MINING AND PROCESSING FACILITY

✓ Therefore, the installation began operating with a nuclear license issued by CNEN without complying with a specific environmental licensing process. This is presently a mandatory step in Brazil (IBAMA did not exist at that time);

✓ To address this situation a Term of Environmental Commitment (TEC) was signed by the mining company, IBAMA and CNEN;

✓ TEC established that the operator must submit to both regulatory authorities a Impacted Areas Recovery Plan.
Impacted Areas Recovery Plan

- Main sources of contamination:
  - Tailings Management Facility (*TMF*);
  - Waste Rock Piles (*WRP*);
  - Open Pit Mining Area;
  - Industrial ore processing and storage facilities.

- Chemical plant treatment of the liquid effluent is still in operation.
Impacted Areas Recovery Plan

- Site characterization and baseline data;
- The four individual areas (AREA 1 - Tailings Dam; Area 2 - Waste Rock Piles nº 4 and 8; Area 3 – Open Pit; Area 4 – Industrial Area) assessed in an integral way;
- Waste characterization;
- Water & Load balance;
- Remediation goals and evaluation criteria;
- Description and assessment of remediation strategy / technical measures;
- Cost estimation;
- Time Schedule.

Submitted for Approval
Total Area of the site: 32 km²
AREA 1
Tailings Dam

Drainage area = 0.23 km²
Total area = 0.86 km²
Total Volume = 2.4 x 10⁶ m³
Total Solid = 2.5 x 10⁶ t
AREA 2
Waste Rock Pile 4

VOLUME = $15,0 \times 10^6 \text{ m}^3$
AREA = $5,7 \times 10^5 \text{ m}^2$
HEIGHT = 90 m
AREA 2
Waste Rock Pile 8

VOLUME = 15,5 x 10^6 m^3
AREA = 6,4 x 10^5 m^2
AREA 3
Open Pit

During Operation

Today
Sludge from the acid water treatment

Total of Removed Rock = 94.5 x 10^6 t
Total of Processed Rock = 1.8 x 10^6 t

D = 2 km
AREA 4
Industrial Area
Some Technical Issues

• The mining site → high precipitation rates;

• Considering the generation of Acid Drainage and the high precipitation rates, great volumes of water need to be treated to avoid undue releases of radionuclides and heavy metals into the environment;

• As a result of the water treatment, large amounts of sludge containing significant levels of radionuclides and heavy metals need to be disposed off;

• Radiological control of the site is maintained by the Operator, especially at effluent discharge points, in particular from the waste dam and the drainage water treatment units from the mining area and waste rock piles.

• The lessons learned from the site closure will impact significantly the operation and closure of future uranium sites in Brazil.
Some Considerations

- Acid Drainage:
  - Results in a very important amount of financial resources spent per year;
  - Additional resources will be needed to implement adequate solutions.

- Relevant information about the site is dispersed;

- Decision needed concerning the dismantling of the industrial area and site remediation.
Challenges

- A well defined mechanism to ensure adequate funding for remediation.
- The assessments and compliance with established safety requirements, e.g., criteria for Unrestricted Release;
- Definition of a site for long term storage of the radioactive waste produced during dismantling and/or decontamination of equipment, materials and buildings;
- Political and psychosocial aspects involved;
- The necessary and appropriate strategy for stakeholder involvement;
Challenges

- Unrestricted release vs Long-term care;
- Inspection and reporting frequency;
- Timeliness of actions;
- Long-Term Control:
  - A long-term surveillance plan;
  - Criteria for instituting long term maintenance;
  - A structured long-term communication programme;
  - Frequency and extent of monitoring.
- Recordkeeping.
Last Remarks

**Project BRA9057**
2014 - 2015

“Strengthening of the Brazilian Regulatory System to Ensure Alignment of the Safety of Nuclear Fuel Cycle Facilities to the Best International Practices”

**Outcome**

The project goal is to ensure that the Brazilian nuclear licensing of NFCF and environmental management are fully aligned to the best international practices.

**Overall Objective**

To strengthen the Brazilian NFCF regulatory system and general safety culture of stakeholders in order to ensure the safe and peaceful use of nuclear energy and ionizing radiations, by means of:

- updating or developing specific standards, guides, procedures, code of practices and inspection protocols;
- improving partnerships among relevant national and international institutions;
- accrediting laboratories; and
- assuring clear information related to the NFCF safety to the civil society.
Strengthening of the Brazilian Regulatory System to Ensure Alignment of the Safety of Nuclear Fuel Cycle Facilities to the Best International Practices

Last Remarks

- National workshop on the regulatory approach and operational safety of mines, emphasizing underground uranium mines, including regulatory oversight and operational issues.
- Expert Visit to Brazil to participate on Workshops and discuss the licensing and the regulatory requirements for the safety of mines, emphasizing underground mines.
- IEX on the following topics: Geotechnical engineering, underground mining engineering, occupational and environmental radiological protection, decommissioning and remediation, accident analysis, safety-related systems, routine operational safety measures, etc.

Activities (Ex.):

“...”
Thank you for your Attention!