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International Mining Legacies: Brazil

Arnaldo Mezrahi
General-Coordinator
Licensing of Nuclear Fuel Cycle Facilities
Brazilian Nuclear Energy Commission - (CNEN)
BRAZIL

5 regions:
- Northeast
- Southeast
- South
- Central West
- North

Source: Matos, J. -Eletronuclear
Population: 197,755,800

made up of many racial and ethnic groups (Indigenous, Portuguese colonists, African slaves and, since the 19th century, immigrants). Portuguese is spoken by all the population and Brazil is the only Portuguese speaking nation in the Americas.

Source: Matos, J. -Eletronuclear

Area: 8,514,215 km² (5th of the world)
Brazil

Largest Cities

- Fortaleza = 2,500
- Salvador = 2,900
- Brasília = 2,800
- São Paulo = 11,900
- Belo Horizonte = 2,500
- Rio de Janeiro = 6,500

Population: 200 million

The fifth most populous country in the world but with a low population density = 22 inh/km²

Source: Matos, J. - Eletronuclear
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).
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 OFFICES IN BRAZIL

Distrito Federal
- Planalto Central District

Goiás
- Central-West Regional Centre of Nuclear Science (CRCN-GO)

Minas Gerais
- Nuclear Technology Development Centre (CDTN)
- Poços de Caldas Laboratory (LAPOC)

São Paulo
- Nuclear Energy Research Institute (IPEN)

Rio de Janeiro
- Headquarter
- Protection and Dosimetry Institute (IRD)
- Nuclear Engineering Institute (IEN)
- Angra dos Reis District (DIANG)

Rio Grande do Sul
- Porto Alegre District

Ceará
- Fortaleza District (DIFOR)

Pernambuco
- Northeast Regional Centre of Nuclear Science (CRCN-PE)

Bahia
- Caetité District
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.

\(\textbf{(*) Nuclear Installation} - \text{Nuclear power plants, Nuclear fuel cycle installations (including mine and processing of Uranium/Thorium) and Research reactors.}\)
Licensing Process (Brazil)

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

**Nuclear installations** are subject to both:

1 - **Nuclear License** - CNEN - (Ministry of Science, Technology and Innovation); and

2 - **Environmental License** - the Brazilian Institute for the Environment and Renewable Natural Resources – IBAMA, with the participation of state and local environmental agencies. (Ministry of Environment)
THE LICENSING PROCESS (NUCLEAR), involves:

✓ The specific characteristics of the country region and details of each project;

✓ Compliance (operator) with general and specific guidelines and regulations, based on national and international experience and requirements;

✓ Environmental and social aspects from the earliest exploration to the decommissioning and remediation of the site;

✓ Stakeholders;

✓ Inspections to monitor compliance;

✓ Annual Reports (occupational, Radioactive Waste Management and Environmental) submitted by the operator to the Authorities.
RESPONSIBILITY OF LICENCE HOLDER

- The Brazilian legislation defines the operating organization as the prime responsible for the safety of a nuclear installation, including the management of spent fuel and radioactive waste.

- To obtain and maintain the corresponding licences, the operating organization must fulfil all the requirements established in the legislation and in the ensuing regulations.

- All nuclear installations licensed by CNEN must have an authorized Radiation Protection Officer.
Uranium Mining and Processing Facilities in Brazil

The first facility, in Poços de Caldas, was operated between 1982 and 1995. All the economically recoverable uranium was extracted and currently no mining activity is underway. The site is being prepared for decommissioning.

A new mining facility has been in operation since 2000 in Caetité, with reserves of 100,000 t of U₃O₈, and a capacity of 400 t/year of yellow cake (U₃O₈) production, which can be expanded to 800 t/year.

The deposit of Santa Quitéria is the largest discovered uranium reserve in Brazil. An estimated 142.2 thousand tonnes of uranium is inter-mixed with phosphates. The mine is planned to produce 1,600 tonnes of U₃O₈ per year as a by-product of 240,000 tonnes of P₂O₅.
Uranium 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)
Poços de Caldas Mining and Processing Facility

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.
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.
Poços de Caldas Mining and Processing Facility

- 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
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 an 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;
- Four individual areas selected (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.
Total Area of the site: 32 km²
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.
The southeast coastal region of Brazil has rich deposits of heavy minerals, the major constituents being zircon, rutile and monazite;

The monazite content of the beach sands generally varies from <0.1 % to 2 %.

Monazite of Brazil origin contains Th as ThO₂, U as U₃O₈ and Rare Earths elements.

The presence of NORM in the rare earth minerals is quite often significant enough to result in occupational and environmental radiation exposures during their mining, milling and chemical processing for the extraction of the rare earth elements, uranium and thorium compounds.
Monazite Processing Industry
Mining, mineral separation and concentration of rare earth ores - 1st Unit
Monazite Processing Industry
Mining, mineral separation and concentration of rare earth ores
1 Unit in Rio de Janeiro State – In operation

✓ Surface mining, collection of beach washings and dredge mining are the mining methods adopted;

✓ The mineral separation plants (MSPs) make use of the differences in the electrical and magnetic properties and differences in specific gravity of the constituent minerals to separate them;

✓ The dredged sand is concentrated by slurrying in water and passing down through spirals;

✓ The dried concentrate is passed through a series of high tension electric separators and magnetic separators of varying intensities;

✓ Wet tabling and froth floatation effect fine separation of some minerals;

✓ During final stages of monazite separation, air tabling also is adopted.
Monazite Processing Industry
Mining, mineral separation and concentration of rare earth ores – 1st Unit Remediation

→ For long-term storage, the sand/monazite bearing wastes are segregated, appropriately transported and stored in trenches;

→ Trenches and periodically topped with mineral free sand to keep the radiation fields up to limit of the natural levels encountered in the area;

→ The mined and refilled areas are replanted and rehabilitated;

→ There is a continuous reforestation programme for restoring the ecological balance to the maximum extent possible.
CHEMICAL PROCESSING OF MONAZITE (2 Units) - SÃO PAULO CITY
Brazil's Largest City - Population 19,000,000 inhabitants
2\textsuperscript{nd} Unit - Began operating in the mid-1940s → Legacy

Production of Rare Earth, Uranium and Thorium concentrates from monazite
Monazite Chemical Processing – 3rd UNIT → Site under remediation
Monazite Chemical Processing – 3rd UNIT

PAST
Monazite Chemical Processing – 3rd UNIT

TODAY

Church
Monazite Chemical Processing – 3rd UNIT
Site Characteristics

✓ 60,000 m²;
✓ Used to:
  • Store material resulting from the research and development of Uranium and Thorium ore processing;
  • Store heavy fractions of the monazite sand processing plant;
  • Dispose of silica residues from the monazite sand processing;
  • Store wastes from the decommissioning of 2nd Unit (older monazite chemical processing plant);
✓ Remediation underway since 2010.
Between 1999 and 2000 remediation actions were performed (red areas);

Clean soil stored to be used for future backfilling (green area);

Two sheds were demolished (blue area).
Monazite Chemical Processing – 3rd UNIT

Survey of the residual contamination

✓ Contamination Assessment;
✓ Groundwater monitoring wells;
✓ Soil and surface water sampling.
Monazite Chemical Processing – 3rd UNIT

Contaminated Soil Monitoring and Removal

30 Cm

90 Cm

60 Cm
Monazite Chemical Processing – 3rd UNIT

Contaminated Soil Monitoring and Removal

Monazite Sand Layer
Characterization surveys according release criteria;
Remedial action support surveys;
Final Report.

Today ➔ The site was partially released for unrestricted use (to be used as accesses to two main roads)
Monazite Chemical Processing – 3rd UNIT

Main Results

✓ The largest volume of contaminants was identified as being heavy mineral sands (monazite mainly);

✓ The soil containing heavy minerals is being processed in the heavy mineral processing plant;

✓ The amount of radioactive waste generated was reduced to 5.2 tons and it is temporarily stored on site;

✓ The radiological control of workers resulted in values below 0.2 mSv/y.
FINAL REMARKS
Specific challenges and needs
- All Legacy Sites -

• The evaluation and demonstration of safety of the remediation project (e.g., dose assessment, site characterization, land use restrictions);

• The establishment of specific regulation defining clearance levels and unconditional release;

• Political and psychosocial aspects related to radioactive waste disposal (e.g., stakeholder involvement);

• Financial provisions;

• Definition of a site for long term storage of the radioactive waste generated.
FINAL REMARKS

Specific challenges and needs
- All Legacy Sites -

New technologies and safety standards have resulted in the need for:
- developing and updating safety regulations and guides, accrediting laboratories, and adopting high-tech measuring equipment and safety assessment software;

- the establishment of common grounds among federal institutions responsible for the licensing of Nuclear Installations, improvement of the technical aspects and reduction of legal competence gaps and overlaps;

- the partnerships with the Technical Support Organizations (TSO) needs to be targeted towards enhancing their technical assistance for the regulatory body, to be achieved through capacity building of the TSO in regulatory issues.
FINAL REMARKS
Specific challenges and needs
- All Legacy Sites -

The main values to be improved aiming at a sustainable development, specially in the mining and processing of uranium and thorium ores legacies sites are:

1. **Care** for the safety, health and well-being of workers, contractors and host communities;

2. **Respect** for the stakeholders and the environment;

3. **Integrity** as the basis for engagement with employees, communities, governments and others;

4. **Accountability** - to do and to uphold commitments;

5. **Transparency** – to work in an open, transparent and inclusive way to address the challenges and opportunities to be faced.
Thank you for your attention!