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REVIEW ARTICLE OPEN ACCESS

SURVEY OF TYPES OF RADIOACTIVE SOURCES IN USE IN BRAZIL AND DISUSED SOURCES IN BRAZILIAN INTERMEDIATE REPOSITORIES FACILITIES

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ABSTRACT

This research aimed to conduct a survey of the types of radioactive sources currently in use in Brazil, as well as disused sources stored in Brazilian waste disposal facilities. This survey is essential for analyzing the capacity for storage, treatment, and final disposal of radioactive sources in the country, thereby promoting better control and possible reuse of radioisotopes employed in several key sectors of society, including agriculture, medicine, mining, industry, research, and education.

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INTRODUCTION

Soon after the discovery of radioactivity, the use of radioactive sources increased significantly, partly due to the realization that they could be employed in various applications such as medicine, industry, and weaponry. To establish proper usage rules and prevent accidents that could harm people and the environment, the National Nuclear Energy Commission (CNEN) was established in 1956 to guide the safe and peaceful handling of such materials in Brazil. Over the years, CNEN established regulations aligned with the guidelines of the International Atomic Energy Agency (IAEA), which has the same mission on a global scale. Consequently, radioactive sources were categorized to facilitate regulation and safety practices. The main categorization consists of five levels: from high-risk sources (category 1), capable of causing severe health and environmental effects if mishandled, to low-risk sources (category 5), which are less likely to cause major damage. In Brazil, the use of radioactive sources is organized into six major groups: medical, industrial, security, research, commercial, and service sectors. Currently, there are more than two thousand active sources in the country, according to approved CNEN licenses. The following table and chart present the facilities in each area and their percentage relative to the total licensed installations. The country also has four intermediate waste disposal centers supporting the nuclear energy sector: the Nuclear Technology Development Center (CDTN-MG), the Institute of Energy and Nuclear Research (IPEN-SP), the Regional Center for Nuclear Sciences of the Northeast (CRCN-RE), and the Institute of Nuclear Engineering (IEN-RJ). This study aimed to present a survey of the types of radioactive sources in use in Brazil and those in intermediate storage facilities, highlighting the current situation regarding the number of sources in the country and the existing infrastructure for storage, treatment, final disposal, or potential reuse.

MATERIALS AND METHODS

This study employed a descriptive research method to analyze radioisotopes used in Brazil. The research was based on documents published by CNEN to identify the types, practices, and purposes of radioactive sources in licensed facilities across the country. Data were analyzed alongside IAEA guidelines. A questionnaire was also sent to professionals working at these

Table 1. Categorization of Sources by the National Nuclear Energy Commission (CNEN).

Medical field	Industrial Field	Security Field	Research Applications	Commercial Field	Services Applications
Blood irradiation (26)	Irradiation by Radiation Generating Equipment (14)	Portable Backscatter Inspection Devices (11)	Research Laboratory (193)	Source Storage (2)	Instrument Calibration Laboratory (7)
Nuclear medicine (457)	Irradiation by Source (7)	Distribution of Security Equipment (12)		Distribution of Device with Non-Sealed Incorporated Source (2)	Individual Monitoring Laboratory (4)
Radioimmuno assay (RIA) (6)	Nuclear Gauges- Process Control (495)	Body Scanning (214)		Distribution of Device with Sealed Incorporated Source (24)	Maintenance of Emitting Equipment (21)
Radiotherapy (286)	Nuclear Gauges - Portable Systems (13)	Baggage and Container Inspection (66)		Distribution of Radiation Generating Equipment (12)	
	Well Logging (12)	Maintenance of Security		Source Distribution(2)	
		Equipment (16)			
	Industrial Radiography (87)	Other Security Equipment (1)		Radiopharmaceutic als Distributor (4)	
	Analytical Techniques (103)			Radioisotope Production (Cyclotron) (12)	
	Industrial Radioactive Tracers(3)			Radiopharmacy (3)	
	Source Replacement (1)				
Total: 775	Total: 735	Total: 320	Total: 193	Total: 61	Total: 32

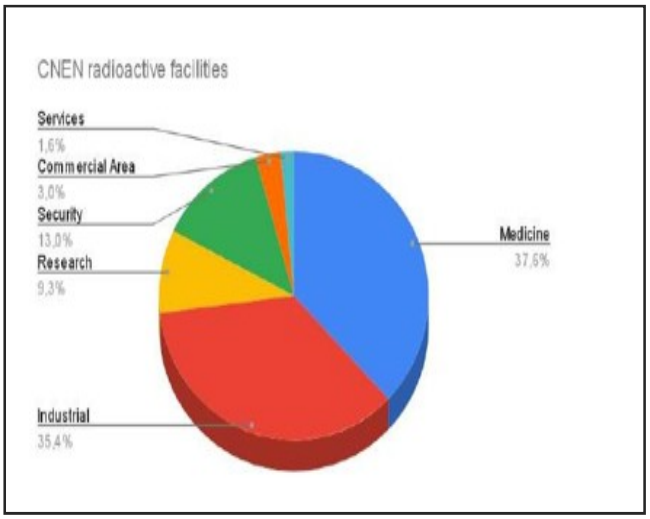
facilities to gather information about the infrastructure, operation, capacity, and safety of intermediate radioactive waste repositories, following current regulations. This step aimed to fill informational gaps not covered by bibliographic or database sources.

RESULTS

The table and chart below show the Brazilian facilities categorized according to their use and area of application (Data were collected in August 2024). The following graph illustrates the most frequent radionuclides sent to Brazilian intermediate facilities, according to the survey conducted:

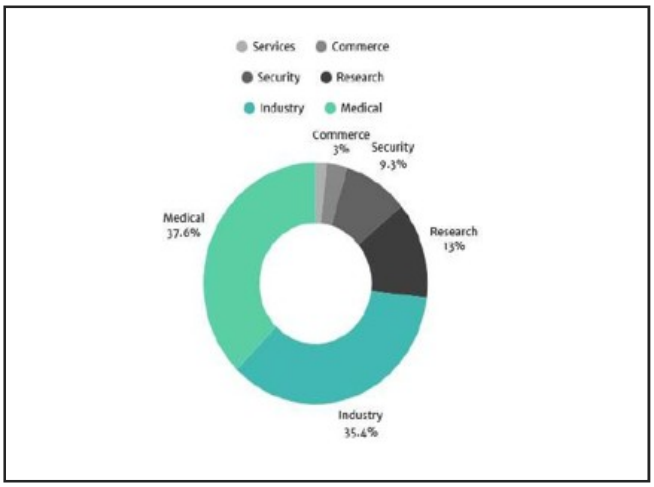
Figure 1. Categorization of Sources by the National Nuclear Energy Commission (CNEN)

CATEGORY	SOURCES AND PRACTICES
1	Thermoelectric Radioisotope Generators (RTG); Irradiators (large-scale, blood and tissue, calibration); Teletherapy Sources, "Gamma Knife."
2	Industrial Radiography Sources; High and Medium Dose Rate Brachytherapy Sources.
3	Fixed Gauges using High-Activity Sources; Borehole Logging Sources.
4	Low Dose Rate Brachytherapy Sources; Industrial Gauges with Low-Activity Sealed Sources; Bone Densitometers; Static Electricity Eliminators
5	Beta Therapy Sources; Mössbauer Spectrometry; Calibration Sources.



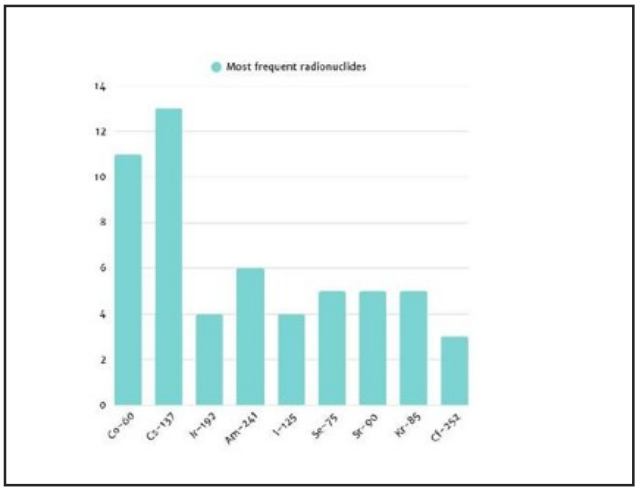
Source: Personal Archive.

Figure 2: Proportion of radiative facilities in the country (Data collected in August 2024)



Source: Personal Archive.

Figure 3. Proportion of radiative facilities in the country



Source: Personal Archive.

Figure 4. Most frequent radionuclides.

Table 2: Number of facilities in operation in Brazil and their respective areas of application

Instalações CNEN	Quantidade
Médica	775
Industrial	730
Segurança	192
Pesquisa	268
Comércio	62
Serviços	33
Total:	

DISCUSSION

The distribution of radioactive source installations in Brazil demonstrates a clear predominance of applications in the medical and industrial sectors. According to the dataset, medical facilities account for approximately 37.6% of installations, while industrial applications represent 35.4%. Overall, the distribution suggests that Brazil's regulatory and operational infrastructure is heavily oriented toward healthcare and industrial technologies. In parallel, the analysis of the most frequently used radionuclides in the country reveals a strong reliance on well-established isotopes. Cs-137 and Co-60 are the most prevalent, consistent with their routine application in industrial radiography, irradiation processes, and calibration procedures. Radionuclides such as Ir-192, Am-241, I-125, and Se-75 appear at intermediate levels, reflecting their specialized roles in brachytherapy, quality control, and scientific instrumentation. The presence of isotopes like Kr-85 and Cf-252, although less common, indicates the existence of advanced or niche applications within industrial and research environments. The overall pattern suggests a stable and traditional radionuclide profile, aligned with internationally recognized practices.

CONCLUSION

The study confirms that Brazil complies with IAEA standards for the use of radioactive sources, especially categories 3, 4, and 5 radionuclides, which are widely used in nuclear medicine and industry as reference sources. The research showed that the waste repository facilities have the infrastructure to store and manage these materials in accordance with current standards. However, there is a clear need for greater attention to intermediate repository facilities, given the growing demand caused by exhausted sources from licensed and operational radioactive facilities. This highlights the need to expand capacity and/or establish a final repository for radioactive waste within a short timeframe, as foreseen in the federal government's CENTENA project. In this context, investing in strategies and technological innovations for the treatment and conditioning of exhausted sources (radioactive waste) is essential to minimize volume and increase the storage capacity of intermediate and final repositories. Alternatives, such as producing Ac-225 from Ra-226 needles, may represent viable options to reduce the number of stored exhausted sources.

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CONFLICT OF INTEREST: All authors declare that they have no conflicts of interest.

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