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A historical overview: radiological and nuclear preparedness needs – safe and adequate country response

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1. Introduction

The applications of nuclear energy in its various possibilities, from the production of electrical energy to its use in research, industry, medicine and agriculture, have seen considerable progress throughout the world. Such growth may continue, due the fact of its applications can contribute to the reduction of greenhouse gas emissions by replacing energy sources traditionally powered by non-renewable energy. Brazil has a robust and constantly developing nuclear program, where licensing and control responsibilities are in charge of the regulatory body and the operations of nuclear and radioactive installations are in the responsibility of their respective authorized operators. In this context, accidental events involving such installations can increase the consequences for their surroundings, affecting the environment and the population. These require structuring of resources for response and mitigation at a regional and national level. The response to nuclear or radiological emergencies demands joint participation of professionals from different areas of knowledge.

2. Methodology

A bibliographical research was conducted, focusing on specialized literature on emergency response, using existing material from the International Atomic Energy Agency (IAEA). In this repository, there are compendiums on the main nuclear and radiological occurrences around the world, which steer to clarification of various aspects regarding accidents and incidents, such as situational alert, mobilization, team support, deployment, medical needs, remediation, damage mitigation and lessons learned. About the lessons, safety standards were developed and improved, serving as a basis for Member States of the international organization [1].

Still in this exploratory research, Brazilian legislation and from National Nuclear Energy Commission (CNEN) was consulted, dealing with the topic “emergency response”; notably from the perspective of notification of occurrences [2] and assistance between States [3]. Thus, Internal Guidance (“Orientação Interna” - OI) [4] on the subject was essential, combined with an administrative process conducted at the institution [5], detailing the need for a training program for its professionals. Such actions were the methodological support for the research that aimed to map the preparation of teams for such services.

3. Results and Discussion

Despite the high degree of safety of nuclear technology, some radiologic accidents and emergencies events that have occurred in the past have brought links that have been identified and have been used to increase the reliability of this technology [1].

3.1 Three Mile Island - USA (03/28/1979)

The accident in unit 2 of the Three Mile Island (TMI) nuclear plant, in Pennsylvania, USA, occurred due to failure of the water pump supplying the steam generator, caused by its state of conservation and operational error.

Some lessons were identified:
1. Need for integration of Conventional and Nuclear Emergency Plans;
2. Need for a well-defined chain of command established in the planning phase;
3. Importance of communication with the media, with the existence of a single spokesperson;
4. In Brazil, the creation of SIPRON (Brazilian Nuclear Program Protection System) which considered all these topics.

3.2. Chernobyl - USSR (04/25/1986)

Critcal design and mainly operational mistakes lead to Chernobyl nuclear accident, the worst ever to happen in history, reaching level 7 on the INIS scale, the largest on that. It was the nuclear accident that caused the greatest number of deaths, huge environmental impact and incalculable economic and financial losses. A study detailed information from a working group, from the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), recognized that the Chernobyl accident was responsible for around 4,000 deaths.

3.3. Fukushima - Japan (03/11/2011)

The accident began due to the effects of an 8.9 magnitude earthquake that occurred near the northwestern Japanese coast. Reactors 1, 2 and 3 were automatically shut down at the time of the earthquake, while the nuclear plant's three remaining reactors were already shut down for maintenance.

In the aftermath, the reactors at the Fukushima-Daiichi plant that were still operating were turned off automatically. Due to the lack of water cooling, reactors 1, 2 and 3, although not operational, heated up, leading to partial meltdown of the core and hydrogen explosions destroyed the structure's coating upper part of the containment buildings.

3.4 Three Peruvian accidents

Yanango (1999), Chilca (2012) and Ventanilla (2014) were occurrences that resulted in an enormous global effort and, mainly, in Latin America; in terms of preparing teams, aligning protocols and regulatory reviews. Many professionals were deployed to support not only the victims, but also the professionals who dealt directly with the radioactive sources of the incidents and with the entire regulatory framework. It is worth highlighting that the occurrences were successive in the same nation, with similar characteristics among the incidents.

3.5 Goiânia accident, 1987 - a new paradigm

On September 13, 1987, a source of cesium-137 was removed from its casing. The source, of North American origin, was part of a teletherapy equipment, that had been left, abandoned, in the old facilities of the Instituto Goiano de Radioterapia, in Goiânia. Five days later, the source was ripped from its protective shield and sold to a junkyard. On 09/21/1987, the capsule, previously damaged, was open. Fragments of the source were distributed to people in other areas of the city. Individuals were irradiated directly from the source and were externally and internally contaminated by cesium-137 [6].

CNEN employees evacuated affected areas and began identifying people who had been exposed. CNEN immediately sent teams to Goiânia for an action plan, including monitoring affected people and taking the appropriate measures; in addition to sizing and controlling contaminated areas. CNEN mobilized all its available resources and an emergency response center was activated.

Brazil informed the IAEA of the emergency and requested assistance. Until 1987, the IAEA had counted 17 nuclear and radiologic accidents worldwide, with 59 fatalities. The Agency cites it as the most significant radiological occurrence, concerned to those that occurred in Mexico (1962 and 1983), Algeria (1978) and Morocco (1983). It should be noted that in order to face the emergency in Goiânia, it was required a fast and gigantic mobilization of personnel, totaling 723 people working in the period of just 3 months, with more than 130 thousand hours worked.

3.6 Lessons learned

The Goiânia radiologic accident brought lessons to Brazil and the world, namely:
1. The site has to be well established and its environment studied in detail;
2. The postulated accidents must be very well described;
3. The logistical and human resources infrastructure: present on real time;
4. There must be a management system, with its chain of command clearly identified.

The consequences of a radiological accident are directly proportional to the time elapsed between the start of the accident and its effective identification. Knowledge of the physical and chemical properties of the radioactive source is a factor extremely important to guide response actions. An adequate information system is essential for mitigating rumors and panic. Each country must be properly prepared to receive international aid. Courses and training in response to radiological emergency situations must be conducted for all responders.

By IAEA, the following are considered objectives in emergency response [7]:

- Regain control of the situation and mitigate its consequences;
- Save lives;
- Avoid or minimize severe deterministic effects;
- Provide first aid, medical treatment for critical situations and manage treatment to injuries caused by ionizing radiation;
- Reduce the risk of stochastic effects;
- Keep the population informed and maintain public trust;
- Mitigate, as much as possible, non-radiological consequences;
- Protect, as much as possible, properties and the environment;
- Prepare, as much as possible, for the return of social and economic activities to normality.

3.7 Structure of the country to respond to emergencies

Among other links identified by the response to the Goiania radiologic accident in 1987, it may be said that the country has awakened to the need to better prepare itself to respond to any nuclear accident or radiological emergency, regardless of the root cause. CNEN has activated the Nuclear and Radiological Emergency Response System (SAER). SAER was recently restructured by a guideline, Orientação Interna (Ol) PR-002/2022 [4].

Two questions should be answered to a fruitful, comprehensive SAER coordination.

- What is the challenge? Answer: acting promptly to any events of a radiological or nuclear nature that affect the country, in a coordinated way, integrated with national organizations (and international ones, whether necessary) that play roles in responding to emergency situations.

- Is Brazil prepared? Answer: considering: (i) the country's continental dimensions; (ii) the lessons identified in the response to Goiânia accident (figures 1 and 2); (iii) the occurrence of other accidents in the world, especially in Latin America, their causes and consequences; (iv) CNEN standards; (v) IAEA recommendations, in particular those contained in the GSR Part 7 document, it can be said that Brazil has achieved a prominent role in the area of preparedness and response for nuclear and radiological emergencies, recognized by IAEA and Latin America region. However, even though a system currently has more than two dozen qualified specific professionals, with available personal protection equipment and functional cell phones, the paradigm of a greater number of trained and re-trained responders demonstrates the professional seriousness in dealing with such important question. World practices show that the quantity and quality of personnel employed “makes the difference”.


Figures 1 and 2: Decontamination work by CNEN teams - Goiânia, 1987.

4. Conclusions

Circumstances such as those reported herein occur around the world and require the attention of national authorities. Brazil, as a regional leader, with primacy in number of operating facilities in the nuclear sector and holding the largest number of qualified people in Latin America, is permanently achieving an adequate level of preparation for responding to nuclear and radiological accidents, as recommended in the publication GSR Part 7, General Safety Requirements, from IAEA.

A continuous training program was implemented by CNEN, reaching out its employees and becoming imperative for the organization; to continue playing this leading role in responding to radiological and nuclear emergencies that may eventually occur in any region of the Brazilian territory.

The SAER must be a solid, efficient tool, empowering the strength of nuclear activities under the responsibility of CNEN and the country. CNEN presently carries on a training program, in order to provide a whole response system, gathering operational and administrative servants as well.

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