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# CURRENT STATUS OF INTERNAL DOSIMETRY SERVICE LABORATORIES IN BRAZIL

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## ABSTRACT

Several Technical Documents related to internal dosimetry have been released by the IAEA and ICRP after nuclear and radiological accidents, such as the Chernobyl and Goiânia. However, standard bioassay procedures and methodologies for bioassay data interpretation are still under discussion and, in some cases, not well understood by the professionals involved in this specific field of radiation protection. Therefore, both in routine and emergency monitoring, responses may differ markedly among Dosimetry Laboratories and it may be difficult to interpret and use the bioassay data generated. The resulting misunderstanding can impair countermeasures and remediation operations and enhance significant socio-economic and political consequences. Currently it is recognized worldwide the need to have a realistic evaluation of the reliability of the services provided by specific laboratory as well as a clear compliance with best practices and a permanent effort to improve data interpretation. The objective of this work is to ensure regular and systematic quality monitoring of the Accredited Laboratory Network composed by the Brazilian governmental Institutes which will comprise expert teams able to provide, upon request, reliable services in case of a radiological accidents and follow-up operations, as well as internal dose evaluation of occupationally exposed workers.

## 1. INTRODUCTION

Individual monitoring is an essential practice for those who work in nuclear activities [1, 2]. Intakes of radioactive material are normally assessed routinely for workers employed in areas that are designated as controlled (specifically in relation to the control of contamination) or in which there are grounds for expecting significant intakes [2, 7]. One critical problem is the confidence in the measurements done by the laboratories in charge of such tasks.

However, there are difficulties in comparing data on doses due to intakes of radionuclides in different countries because of different approaches used to monitor and interpret results.

Procedures can vary from one laboratory to other, introducing lack of confidence in the information provided to radiation protection officers, to the own worker and to competent authorities. Standard procedures for laboratories related to dosimetry and analytical methods are now freely available through the IAEA [3, 4, 5].

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Several international intercomparison exercises for internal dose assessment have been organized, of which the largest one so far was the Third European Intercomparison Exercise on Internal Dose Assessment, organized in the framework of the EULEP/EURADOS Action Group [6]. The most important lesson from these intercomparison exercises was the need to develop guidelines for internal dose evaluation procedures in order to promote harmonization of assessments between organizations and countries. Significant differences were revealed among laboratories in their approaches, methods and assumptions, and consequently in their results. One major source of divergence at the time of the exercise was due to particular ICRP models used. Most dosimetry services were operating using models from ICRP Publications 26 [8] and 30 [9] for legal reasons. However, most were in the process of moving to new generation of ICRP models (Publications 56 [10], 60 [11], 66 [12], 67 [13], 68 [14], 69 [15], 71 [16], 72 [17], 78 [18], and 100 [19]), partly because these are considered to be more realistic and partly because of the eminent implementation of the International Basic Safety Standards [20] and new EURATOM directive, which are based on the new models [21, 22, 23, 24, 25]. Similar projects aiming to harmonize internal dosimetry procedures have been carried out in different parts of the world under the auspices of the International Atomic Energy Agency (IAEA) [26].

Administrative routines and laboratory procedures related to implementation and maintenance of quality assurance are stated by internationally accepted requirements established by the ISO/IEC-17025 (General requirements for the competence of testing and calibration laboratories). Implementation of ISO/IEC-17025 requirements is the unique condition to obtain accreditation since it is the basis for the recognition of technical competence of any calibration or assay laboratory, which is the case of the Brazilian internal dosimetry laboratory network.

This work describes the implementation of a National Network of Laboratories aimed to perform radiological internal monitoring measurements in Brazil. The establishment of standardized radioanalytical techniques and dose assessment procedures among the network and the implementation of the ISO/IEC 17025 requirements will result in reliable dose assessment and in the recognition of technical competence of the laboratories. It is expected that the main beneficiaries of this network will be: workers that manipulate unsealed sources of radionuclides in several nuclear applications such as industry, medicine, and research; members of the general public in case of accidental releases of radioactive materials; national regulatory authorities and stakeholders in the nuclear area; and internal dosimetry services.

## 2. MATERIALS AND METHODS

Current available internal dosimetry services in Brazil consist of eight laboratories installed in governmental institutions under administration of three Ministries: Science and Technology; Navy, Mines and Energy. Such institutions include four research centers, Institute for Radiation Protection and Dosimetry (IRD), Nuclear Energy Research Institute (IPEN), Poços de Caldas Laboratory (LAPOC), and Nuclear Technology Development Center (CDTN) linked to the Brazilian Nuclear Energy Commission (CNEN). The other two laboratories of the network are located at the Navy Technology Center (CTMSP) and at the Nuclear Power Plant in Angra dos Reis (CNAAA). Figure 1 presents a scheme of the Brazilian administrative structure in which the laboratory network is implemented.

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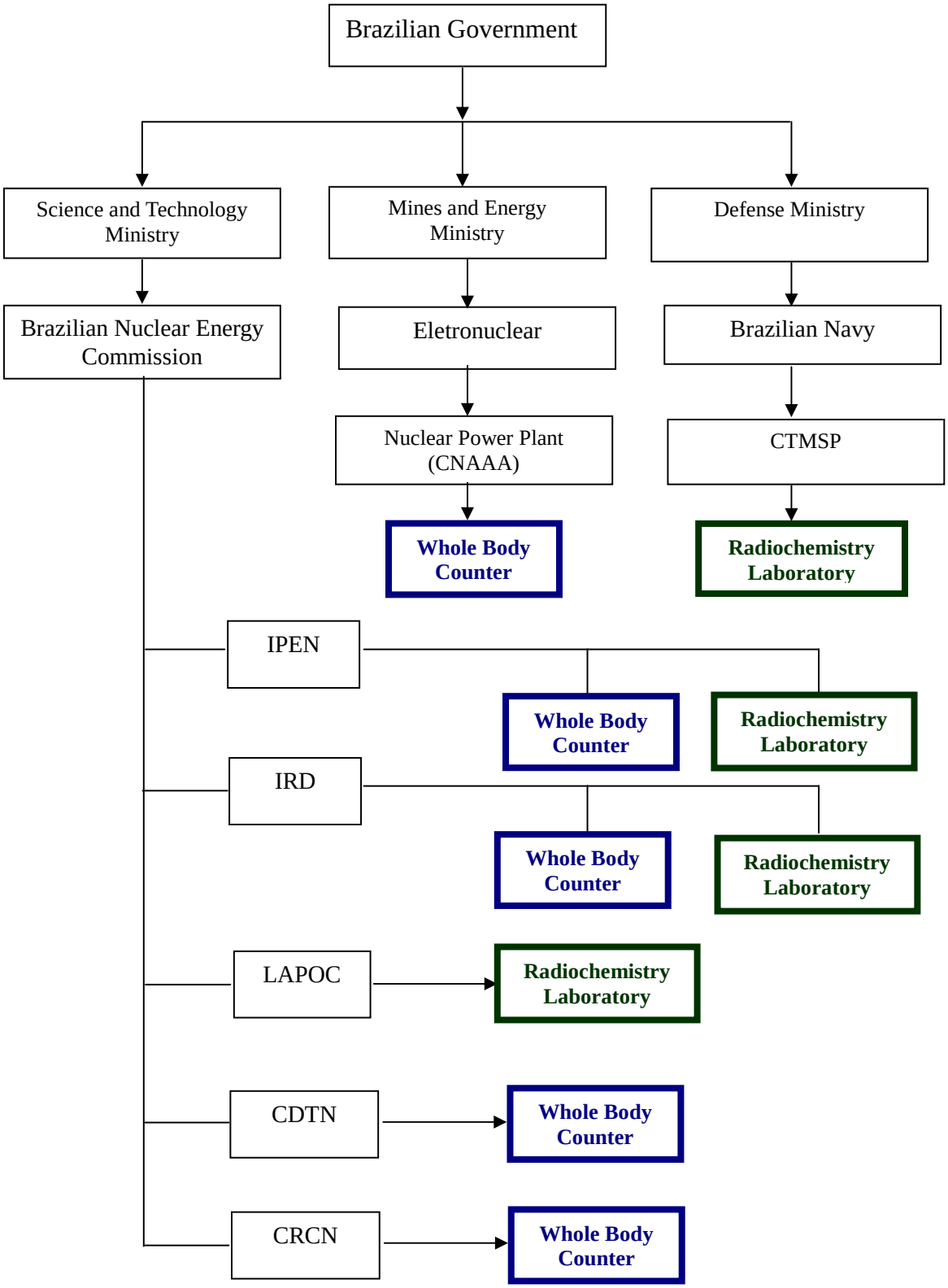


**Figure 1: Administrative structure of Brazilian laboratory network**

The eight laboratories included in the network can be divided into two groups depending of the bioassay technique they apply to estimate intake of radionuclides in human body, i.e., in vivo or in vitro laboratories. Table 1 summarizes selected basic information on the available infrastructure.

**Table 1: Current status of internal dosimetry laboratories in Brazil**

| Laboratory | Facilities | Detection systems | Techniques | MDA[a] |
|---|---|---|---|---|
| IRD<br>Whole body counter | 1 shielded room,<br>1 open room,<br>1 mobile system,<br>1 portable system | 3 NaI (Tl) 8x4,<br>3 NaI(Tl) 3x3<br>4 HPGe | High and low energy photon emitters in the whole body and in organs | $^{137}$Cs (whole body) = 88 Bq<br>$^{60}$Co (whole body) = 86 Bq<br>$^{131}$I (thyroid) = 23 Bq<br>$^{123}$I (thyroid) = 3.5 Bq<br>$^{18}$F (whole body) = 32 Bq<br>$^{18}$F (brain) = 7.5 Bq<br>$^{238}$U (lungs) = 46 Bq<br>$^{235}$U (lungs) = 6.5 Bq<br>$^{241}$Am (lungs) = 7 Bq<br>$^{210}$Pb (skull) = 16 Bq<br>$^{210}$Pb (knee) = 5 Bq |
| IPEN<br>Whole body counter | 1 shielded room | 1 NaI (Tl) 8"x 4"<br>1 NaI (Tl) 3"x 3" | High-energy photon emitters in the whole body and thyroid | $^{99m}$Tc (whole body) = 70 Bq<br>$^{123}$I (thyroid) = 40 Bq<br>$^{131}$I (thyroid)= 10 Bq |
| IRD<br>Bioassay Laboratory | 2 Radiochemistry Laboratories,<br>2 Instrumentation Laboratories | 1 HPGe,<br>1 NaI (Tl) 3x3,<br>4 Surface Barrier,<br>1 Alpha-Beta system<br>1 Liquid scintillation | Uranium and thorium isotopes, $^{226}$Ra, $^{210}$Pb, high-energy photon emitters in urine and feces, $^{3}$H, $^{14}$C, $^{90}$Sr, and $^{210}$Po in urine. | Unat (urine)=0.01 μg.L$^{-1}$<br>Thnat (urine)= 0.02 μg.L$^{-1}$<br>$^{238}$U (urine) = 1 mBq.g$^{-1}$<br>$^{234}$U(urine)= 1.4 mBq.g$^{-1}$<br>$^{235}$U(urine)= 1.4 mBq.g$^{-1}$<br>$^{232}$Th(urine) = 1 mBq.g$^{-1}$<br>$^{226}$Ra (urine)= 3 mBq.L$^{-1}$<br>$^{226}$Ra (feces)= 3 mBq.g$^{-1}$<br>$^{210}$Pb (urine)= 4 mBq.L$^{-1}$<br>$^{210}$Pb (feces)= 4 mBq.g$^{-1}$<br>$^{210}$Po (urine)= 4 mBq.L$^{-1}$ |
| IPEN<br>Radiochemistry Laboratory | 1 Radiochemistry laboratory | 4 Digital fluorimeter,<br>1 Alpha spectrometer<br>1 liquid scintillation,<br>1 Gamma spectrometer | Uranium, thorium, $^{131}$I and $^{3}$H in biological samples | Unat (urine) = 1 μg.L$^{-1}$<br>$^{234}$U (urine) = 3 mBq.L$^{-1}$<br>$^{238}$U (urine) = 5 mBq.L$^{-1}$<br>$^{232}$Th (urine) = 1 μBq.L$^{-1}$<br>$^{3}$H (urine) = 5 Bq.L$^{-1}$ |
| LAPOC<br>Radiochemistry Laboratory | 1 Radiochemistry laboratory | 3 gamma spectrometers,<br>1 ICP-OES,<br>1 Alpha Spectrometer with 8 surface barrier detectors,<br>1 Liquid Scintillation system,<br>1 Ultra Low Level Alpha Beta Counter | Uranium and thorium isotopes, actinides, gamma emitters, $^{90}$Sr, $^{14}$C and $^{3}$H in biological samples | $^{234}$U, $^{232}$Th, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Am<br>Det. Limit = 0.04 mBq.L$^{-1}$<br>3H (urine) = 1.7 Bq.L$^{-1}$<br>$^{14}$C (urine) = 0.1 Bq. L$^{-1}$<br>$^{90}$Sr (urine) = 4 Bq.L$^{-1}$<br>$^{137}$Cs, $^{134}$Cs, $^{60}$Co, $^{113}$Sn, $^{133}$Ba, $^{152}$Eu, $^{54}$Mn<br>Det. Limit = 1 Bq.L$^{-1}$ |
| CTMSP<br>Radioecology Laboratory | 1 Radiochemistry laboratory | 1 Gamma and alpha spectrometry system,<br>1 Total alpha, beta and gamma system,<br>1 fluorimeter,<br>1 liquid scintillation | Uranium decay series in biological samples | Unat (urine) = 1μg.L$^{-1}$ |
| CDTN<br>Whole body counter | 1 shadow shield whole body counter | 1 NaI (Tl) 6"x 4" | High energy photon emitters in the whole body | $^{18}$F (thorax) = 8.6 Bq |
| CNAAA<br>Whole body counter | 1 Fast Scan Whole Body Counter | 1 NaI(Tl) 3”x5”x16” | High energy photon emitters in the whole body | $^{60}$Co (whole body) = 150 Bq |

Intercomparison exercises on in vivo and in vitro radioanalytical techniques and internal dose assessment will be scheduled in the process of implementing the network, in order to demonstrate their competence and verify conformity with the established requirements.

The network has requested financial support from International Atomic Energy Agency (IAEA) through a National Project in order to access other laboratories that have already implemented good practices and procedures. Official support from IAEA will allow the interchange of knowledge provided by fellowships, scientific visits and participation of foreign experts in training courses, as well as acquisition of imported standards and equipment. IAEA support is also important to facilitate intercomparison of results from laboratories located in developed countries.

## 3. RESULTS

The proposed network should provide the following goals in order to capacitate individual laboratories and the staff to obtain accreditation from national and international quality assurance agencies:

- Provide access to good metrological practices,
- promote international recognition of the Brazilian Metrological System,
- offer conditions for human resources capacitating programs in applied radioprotection metrology,
- allow harmonization of measurements among national laboratories through guidance on the use of metrological tools,
- keep contact with international agencies to exchange technical information and related services,
- support legal regulation of materials and products, as well as
- function as a reference forum for metrology issues.

It is recommended that once the laboratories have implemented the authorization system, they should require accreditation of internal dosimetry services by national accreditation agencies affiliated with the International Laboratory Accreditation Conference (ILAC) as a basic requirement. The great advantage of having accreditation and authorization as a combined process is that the system will be optimized.

## 4. CONCLUSIONS

Based on the minimum detectable activities reported it is concluded that the bioassay techniques available among laboratories present, in general, adequate sensitivity for studies related to dose estimation due to the incorporation of most common radionuclides handled in the form of unsealed sources.

It is important to highlight that in vitro bioassay techniques can be applied for any radionuclide from natural series, both for scientific studies of population exposure and monitoring of routine occupational exposure. On the other hand, in vivo measurements are suitable for studies involving long-term exposure of workers to high levels of incorporation, especially in the case of underground mines.

It should also be pointed out that as soon as the network is implemented and fully operational it will promote permanent activities such as training, refreshing courses, and exchange of information among laboratory staff. Such strategy will help keeping network human resources up-to-date with new developments in terms of analytical methods and internal dosimetry techniques. Another activity to be carried out in a permanent basis is the organization of regular in vivo, in vitro, and internal dose assessment intercomparison exercises. It is finally expected that the laboratories will be able to request accreditation by a recognized testing, inspection, and certification organization.

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