Implementation of a Laboratory Network for Internal Monitoring of Radionuclides in Human Body

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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. 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

KEYWORDS: Bioassay techniques, Internal dosimetry, Laboratory accreditation, ISO17025

1. Introduction

Individual monitoring is an essential practice for those who work in nuclear activities [1, 2]. One critical problem is the confidence in the measurements done by the laboratories in charge of that task. Procedures can vary from one laboratory to other, introducing lack of confidence in the information provided to the radiation protection officers, to the own worker and to the competent authorities. Standard procedures for laboratories related to the dosimetry and to the analytical methods are now freely available through the IAEA [3, 4, 5].

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 agreed 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

Administrative routines and laboratory procedures related to the implementation and maintenance of quality assurance are stated by internationally accepted requirements established by the ISO/IEC-17025 and others. The implementation of ISO/IEC-17025 requirements is a necessary and sufficient condition to obtain accreditation since it is the basis for the recongnition of technical competence of any calibration or assay laboratory, which is the case of the Brazilian internal dosimetry laboratory network.

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]. However, there are difficulties in comparing data on doses due to intakes of radionuclides in different countries because of the different approaches used to monitor and interpret the results. 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 agreed 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 the particular ICRP models used. Most dosimetry services were operating using the models from ICRP Publications 26 [8] and 30 [9] for legal reasons. However, most were in the process of moving to the 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 imminent 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].

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 those participant laboratories of the network will result in reliable dose assessment and consequently in recognition of the technical competence of the service.

It is expected that the main beneficiaries of this network are workers who manipulate unsealed sources of radionuclides in various applications such as nuclear industry, medicine and research, members of the public in case of accidents involving release of radioactive materials to the environment, national regulatory authorities and stakeholders in the nuclear area, besides the internal dosimetry services itselves.

2. Materials and Methods

The currently available internal dosimetry services in Brazil consists on eight laboratories installed in governmental institutions under the umbrella of three Ministries: Science and Technology; Navy; Mines and Energy. Such institutions include four research centers, i.e., Institute for Radiation Protection and Dosimetry (IRD), Institute of Energetic and Nuclear Research (IPEN), Laboratory of Poços de Caldas (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.

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.

In the process of implementing the network it is scheduled to organize intercomparison exercises on in vivo and in vitro radioanalytical techniques and internal dose assessment among the laboratories in order to demonstrate their competence and verify conformity with the established requirements.

The network has requested financial support from Internation Atomic Energy Agency (IAEA) through a National Project in order access other laboratories that have already implemented this kind of good practices and procedures. The official support from IAEA will permit the interchange of knowledge provided by fellowships, scientific visits and participation of foreign experts in training courses as well as the purchase of standards and equipment that are imported and usually difficult to obtain via national channels. IAEA support is also important to facilitate inter-comparison between the results of national 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 apply for compliance with national and international quality assurance bodies:

- 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
- work as a reference forum for metrology issues.

It is recommended that once the laboratories have implemented the authorisation system they should require accreditation of internal dosimetry services by national accreditation bodies affiliated with the International Laboratory Accreditation Conference (ILAC) as a basic requirement for the authorisation process by the national regulatory authority. The great advantage in having the accreditation and authorisation as a combined process is that it becomes an optimised system. Otherwise, it is a duplicate process, increasing the costs for the service.

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 the most usual radionuclides manipulated in the form of unsealed sources.

It is important to highlight that in vitro bioassay techniques can be applied for any radionuclide of 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 and refreshing courses and exchange of information through regular scientific visits of the staff among laboratories. 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 among network laboratories. It is finally expected that the laboratories will be able to request accreditation by a recognized testing, inspection and certification organization.

Figure 1: Administrative structure of Brazilian laboratory network

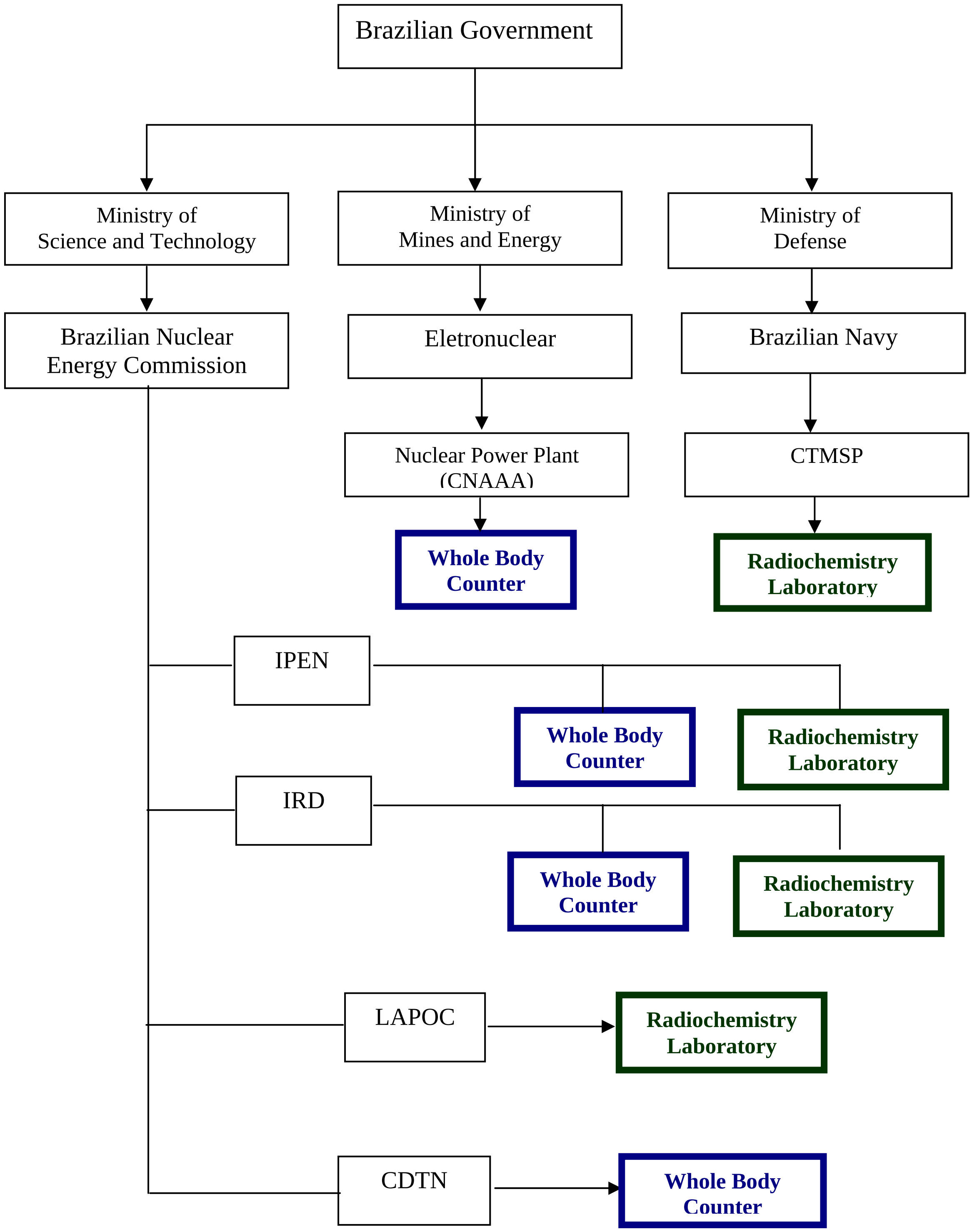

Table 1: Current status of internal dosimetry laboratories in Brazil

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

[a]MDA = Mininum detectable activity

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