

NATIONAL INTERCOMPARISON PROGRAMME FOR RADIONUCLIDE ANALYSIS IN ENVIRONMENTAL SAMPLES: ARAMAR RADIOECOLOGICAL LABORATORY PERFORMANCE

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ABSTRACT

The radioecological laboratory is concerned with the measurements of background radiation (mainly uranium and thorium natural series) and present effluents in the Aramar Experimental Centre, as well as in its surroundings. The laboratory is directly subordinated to the Navy Technological Centre in São Paulo (CTMSP – São Paulo – Brazil), a military research organization whose goal is to develop nuclear and energy systems for the Brazilian naval ship propulsion. The measurements were performed in addition to the Environmental Monitoring Programme carried out in the same region. For this endeavour, the laboratory has attended to the National Intercomparison Programme conducted by the Institute for Radioprotection and Dosimetry (IRD) by analyzing several kinds of solid and liquid samples containing specific radionuclides through gamma spectrometry, liquid scintillation, alpha-beta total counting and fluorimetry techniques, since December 1995. In the last 15 years, our results were compared to another 19 laboratories and rated as “very good” and “acceptable” in at least 90% of the results.

INTRODUCTION

The Aramar Experimental Centre (CEA), located in Iperó, São Paulo – Brazil, is a nuclear development centre belonging to the Navy Technological Centre in São Paulo (CTMSP), whose goals include the development of a fully operational propulsion system for the first Brazilian nuclear submarine, as well as the nationalization of the uranium enrichment process and the domain of nuclear fuel production for the national nuclear power plants.[1]

Given the nature of these activities involving gaseous ultracentrifuges, and although the elimination of liquid and gaseous effluents of the plant takes place in a tightly controlled form, a reliable programme of environmental monitoring is of utmost importance to ensure personnel safety and integrity of the region, from the pre-operational phase of the project until its complete shutdown.

The Radioecological Laboratory (LARE) is the responsible unit for environmental monitoring, internal dosimetry, monitoring of processes and release of the centre's wastewater. Its area of influence extends to a radius of 8 km, including the CEA itself and its

surroundings. Physicochemical, biological and radiometrical parameters are commonly analyzed.

From the radiometric standpoint, to which this work is directly related, the LARE bears the task of monitoring the radiation from elements that are naturally present in the environment, such as ^{40}K and ^7Be as well as uranium and daughters of its decay series. The laboratory also constantly quantifies radionuclides that are specific to human activities, such as ^{137}Cs , ^{60}Co , ^{65}Zn , and ^3H . [2] [3] [4]

The samples of different matrices are collected and prepared by and in the laboratory itself (soil, fish, low vegetation, water milk, crops and air filters), from 124 environmental stations since 1988. [2] [5] [6] [7]

For such task, the LARE has several radiometric analysis techniques that play an important role for the final verdict from the laboratory: gamma spectrometry, liquid scintillation, total alpha-beta counting and fluorimetry. [8] [9]

In order to routinely assess the performance of the LARE, as well as evaluate the general condition of the equipment and methodology, the laboratory participates in a national intercomparison programme (PNI) promoted by the Institute of Radioprotection and Dosimetry (IRD), one of the institutes of CNEN.

The objective of this work is to demonstrate that the LARE has maintained the quality of its radiometric analysis, with the necessary competence and technological conditions to work safely and committed to the environment.

MATERIALS AND METHODS

The PNI conducted every six months requests the determination of natural and artificial radionuclides in environmental matrices. Samples are obtained by diluting aliquots of stock solutions with previously known radionuclides, sent by the Metrology Laboratory of the IRD. The solutions prepared in water matrix are: gamma (^{60}Co , ^{65}Zn , ^{106}Ru , ^{133}Ba , ^{134}Cs e ^{137}Cs), alpha and beta, (^{241}Am , ^{137}Cs), ^3H , ^{90}Sr , U_{nat} , ^{226}Ra , ^{228}Ra , ^{210}Pb e ^{232}Th .

As recommended by the general guidelines of the programme, the LARE reports three results for each category of analysis. The average of these values is compared against a reference value and uncertainty through a standardized z-test, according to Eq. 1. [10]

$$D = \frac{(X - U)}{\frac{su}{\sqrt{n}}} \quad (1)$$

Where,

X = average value of n analysis performed by the laboratory;

U = reference value, regarded as the true value for the measured unit;

su = standard deviation of the reference value;

n = number of repetitions performed by the participating laboratory.

Once the nature of the method returns values that are close enough to a normal curve, this statistic – the calculated z-score – can be used as a reasonable indicator of quality. [11] [12] Mathematically, the amount in question represents the distance between the obtained average from the actual value, later normalized by the reference standard deviation. Hence, the more D approaches zero, the higher the score obtained by the laboratory.

For ease of viewing and categorizing, the IRD classifies the scores obtained by each laboratory in three different ranks: “good” for $|D| \in [0,2]$, “acceptable” for $|D| \in]2,3]$ and “out of control” for $|D| \in]3,\infty[$.

RESULTS

The history of the general analytic performance of the LARE in terms of “good”, “acceptable” and “out of control” is shown in Fig. 1.

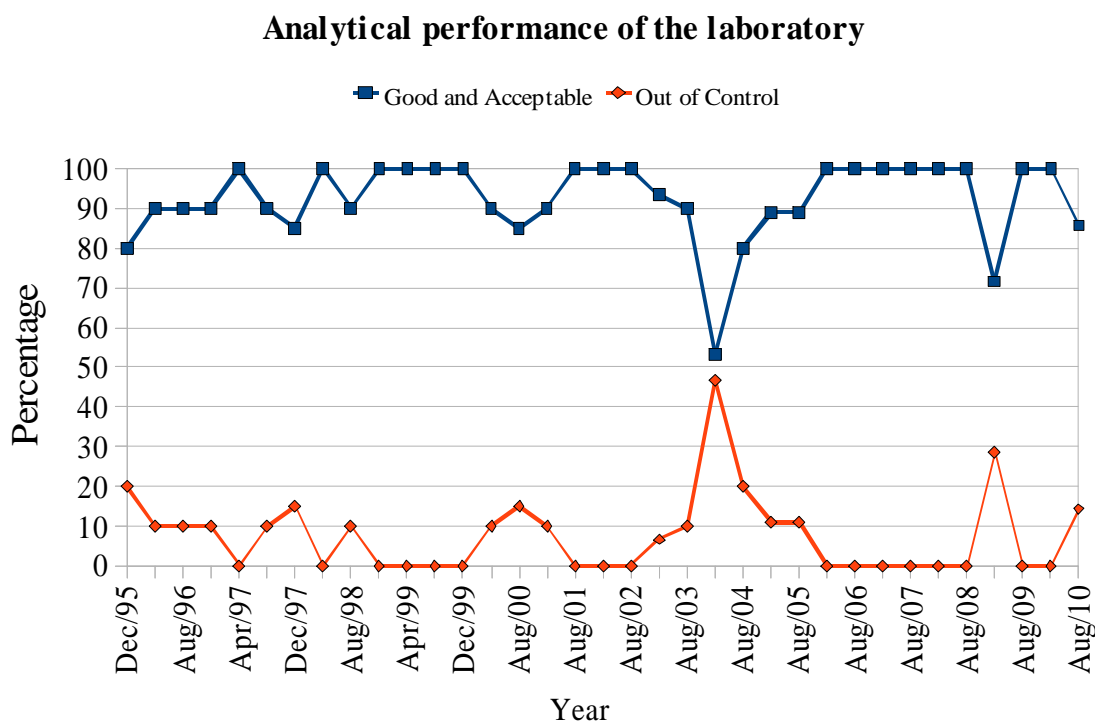


Figure 1 – General performance of the LARE obtained in the PNI, from 1995 to 2010.

The LARE achieved 92.4% of good or acceptable trials in average. As comparison, the grouping Brazilian laboratory performance in the period of 1997 until 2004 observed by IRD shows an average of 80.3%. [13]

Within the average score obtained by LARE, the value of $|D|$ varies largely among the types of analysis, as shown in Fig 2. Since the downfall of 1995 until 2010, the laboratory had performed better at uranium determination in air filters and general radionuclides in water,

and a bit worse at general radionuclides in soil or vegetation and gross alpha counting. Nonetheless, and despite the well-known, poor accuracy of some methodologies such as gross alpha-beta counting [14], all values still fall within the “good and acceptable” region ($|D| < 3$).

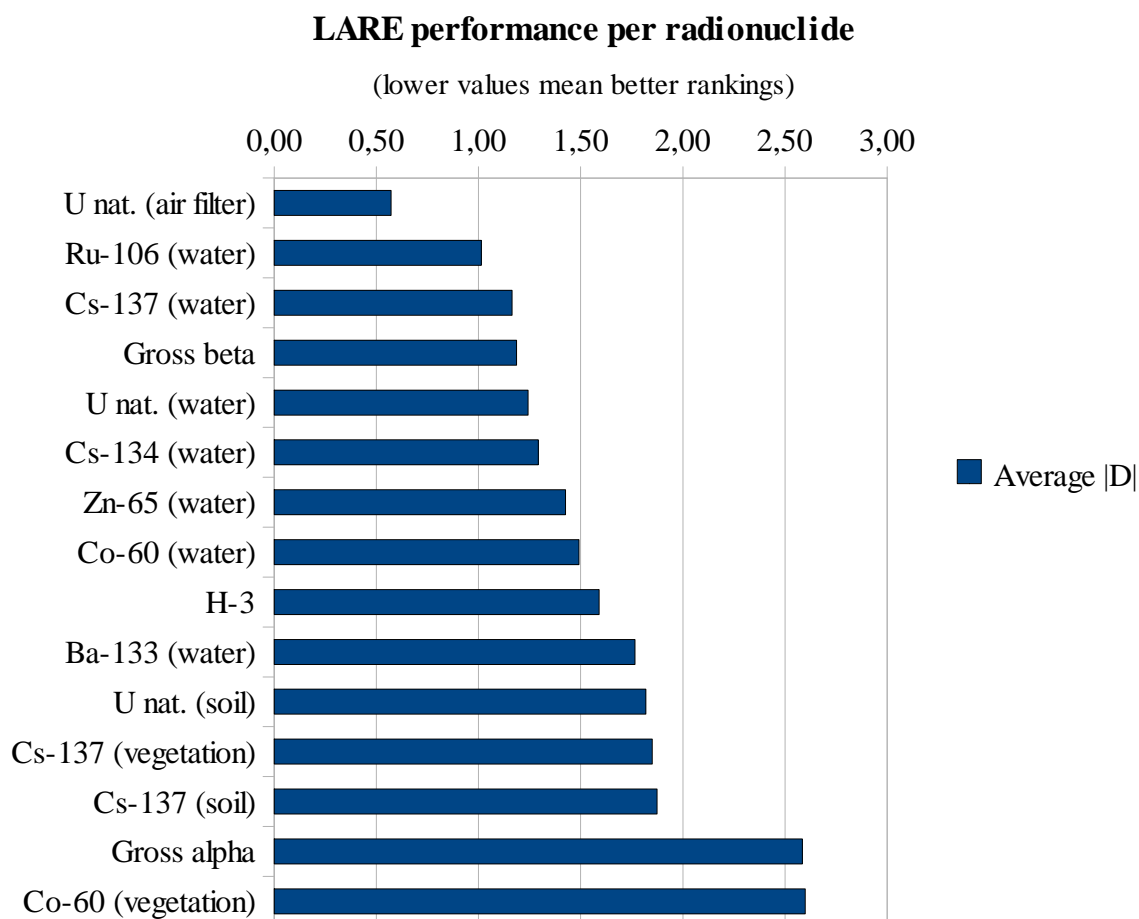


Figure 2 – average absolute values of the D statistic calculated by Eq. 1 for each analyzed radionuclide, from 1995 to 2010.

The comparison of each performance shown in Fig. 2 is consistent with the results reported by other PNI participants. [13]

CONCLUSIONS

The results show a glimpse that the LARE has been obtaining reliable data in the PNI. The participation of this laboratory in intercomparison programmes is one important step towards the ISO17025 accreditation by INMETRO in the near future.

Worth remarking also that the results are compatible with most of other laboratories, suggesting that not only the CEA, but the Brazilian laboratories in general which are involved in nuclear activities have sufficient resources and know-how to participate responsibly in the global scenario of nuclear science.

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