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OVERVIEW OF INTERNAL DOSE EVALUATION IN THE RADIOPHARMACEUTICAL PRODUCTION PLANT AT IPEN

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ABSTRACT

The internal dosimetry program at the Instituto de Pesquisas Energéticas e Nucleares, IPEN, is accomplished in two steps: the activity measurements are performed at the In Vivo Monitoring Laboratory and subsequently the data analysis and the dose evaluation are carried out by the Dose Calculation Group according to the ICRP models. The objective of this study is to take the whole body and thyroid monitoring results recorded from 2005 to 2015 to see whether the internal contamination control procedure for workers were suitable even with the increase in the radiopharmaceutical production. The study were based in a research called "Search of Variables" for the operations carried out in the restricted areas of radiopharmaceutical production plant, taking into account the dose distribution data for all the tasks recorded by the radioprotection service. This methodology aims to identify and determine the principal variables that impact on the worker's dose. The results were presented for the following variables: individual occupationally exposed, operation variable, area/cell, type of task of operation, which depend on the variable dose. In spite of growth rate in the production of radiopharmaceutical, this study has shown that the improvements in the plant have contributed to the dose reduction of the workers.

1. INTRODUCTION

The internal monitoring program of occupationally exposed workers at the Instituto de Pesquisas Energéticas e Nucleares, IPEN, is carried out by in vivo monitoring technique. The group of workers evaluated in this study performs activities in the radiopharmaceutical production plant, CR, for use in nuclear medicine.

Measurements of internal contamination are conducted by In Vivo Monitoring Laboratory, LMIV, and the results are analyzed by the Internal Dose Calculation Group to assess de committed effective dose according to the model proposed by the International Commission on Radiological Protection, ICRP [1]. This procedure is routinely performed, as well as, in cases of suspect of incorporation and the results is recorded and maintained in accordance with national regulation [2].

The paper aims to retrieve the results of thyroid and whole body monitoring recorded during the period from 2005 to 2015 and to make assessment whether the internal contamination control procedure for workers were suitable even with the increase in the production of radiopharmaceuticals.

The study was based on the methodology called variables search, for the different types of operations carried out in the restricted areas of the radiopharmaceutical production plant, taking into account the internal dose distribution for the tasks recorded by the radiation protection service.

1.1 Operations with Unsealed Sources

The production of radiopharmaceuticals is an operation with unsealed sources of radiation and the risk of incorporation of this material cannot be ignored. These activities are carried out in cells which are shielded structures, sealed and equipped with an exhaust system. The production hot cells have three operational facing sides which are: the *production laboratory*, the *high radiation level area* and the *radioactive waste basement*, as illustrated in Fig. 1. The *production laboratories* are classified as supervised areas while the *radioactive waste basement* and *high radiation level area* are classified as controlled areas.

The main production cells are the ^{99}Mo, ^{131}I, ^{123}I, ^{67}Ga, ^{201}Tl, ^{18}F, e ^{153}Sm. [3].

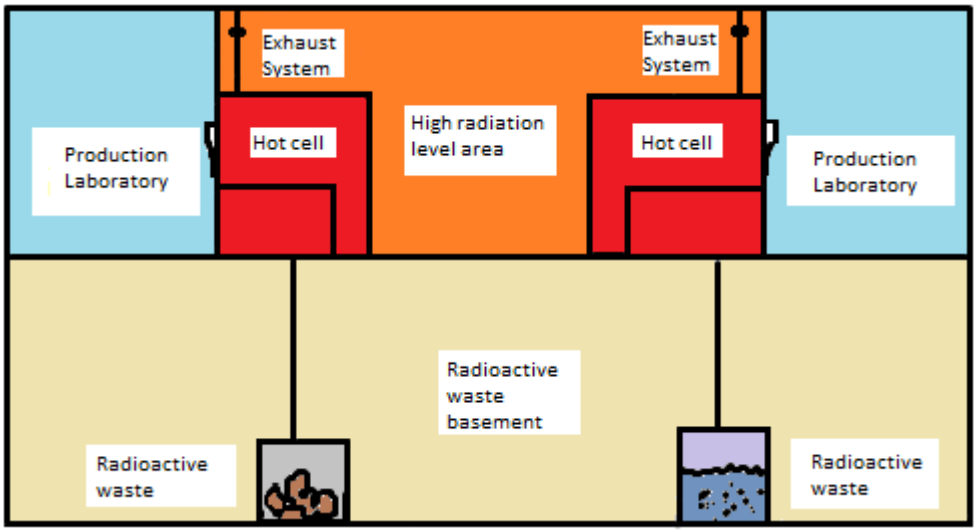

Figure 1: Cross-sectional view of the restricted area showing two radiopharmaceuticals production cells, at Radiopharmaceutical Production Plant of IPEN. The Production Laboratory is classified as supervised areas and the others places as controlled areas.

In addition to the routine activities of production, there are the maintenance operations and also emergency interventions where the procedures are determined according to each situation.

1.2 Control of Occupational Exposure

The control of occupational exposures is performed to external radiation monitoring, surface contamination, air monitoring, and individual dosimetry. This study is focused on control of internal contamination of workers resulting from handling unsealed sources in CR.

The frequency of measurements of individual monitoring for intakes of radioactive materials is defined by the radioprotection service in accordance with the activities that each worker

performs in the facility. Workers who perform the maintenance of the cells are monitored every six months and those who are involved in the production of radiopharmaceuticals are routinely monitored with monthly frequency for internal contamination. In the case of incident or abnormal situation the internal monitoring is carried out promptly. The major routes of intake are the inhalation while the incorporation by ingestion has a minor probability. The individual monitoring for external radiation are held monthly for all workers in the facility.

An effective control of occupational exposures requires a formal training program or training in the workplace.

2. METHODOLOGY

2.1. Materials and Equipment

The incorporation of radionuclides by workers are measured in the thyroid and whole body counter equipped with sodium iodide detectors activated with thallium, NaI(Tl), to detect fótons with energy above 30 keV.

The intake of radionuclides is determined using the software Activity and Internal Dose Estimates, AIDE [4]. These calculations are based on mathematical models recommended by the ICRP, [1] and adopted by the National Nuclear Energy Commission, CNEN [2], in Brazil.

2.1. Variable Search

The data presented in this paper are the result of thyroid and whole body monitoring carried out by LMIV for all the workers which had tasks in the restricted area of the radiopharmaceutical production plant. The information collected was organized by the type of activities performed, the radionuclide handled and intake occurrences. Later this information was classified by variable search [5].

The purpose of variable search is to raise the primary data to provide information relevant to the scope of the research and thus provide secondary data to create statistical and human instrumental, enabling the analysis of the results. This study determined and classified the following variables: task feature, type of handled radionuclide and occupationally exposed individuals as a function the dose resulting from the incorporation of radionuclides.

3. RESULTS AND DISSUTIONS

The numbers of internal monitoring for workers with activities in the radiopharmaceuticals production plant were totalized 5,108 analyses from November 2005 to May 2015 and are presented in Fig. 2. Most of these data were resulted from routinely monitoring and are below the detection limit for whole body and thyroid measurement system.

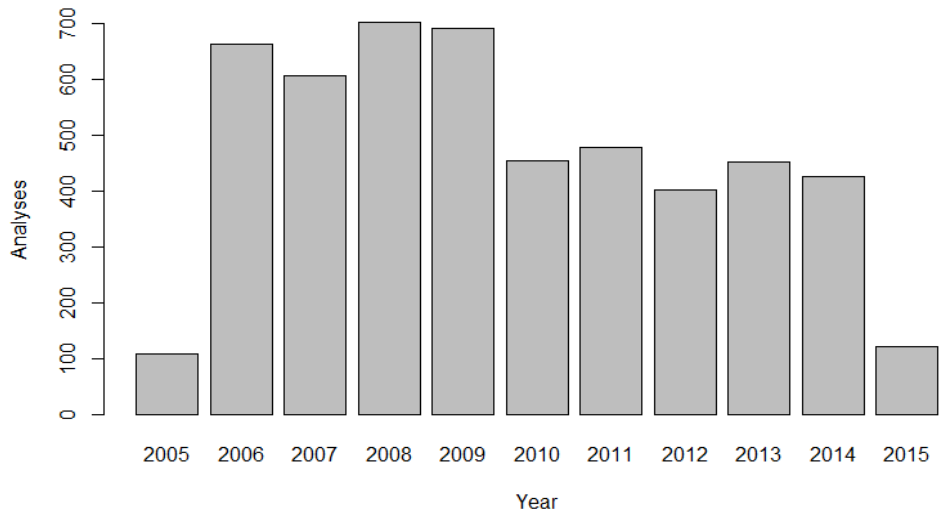

Figure 2: Number of internal monitoring analyses accomplished from November 2005 to May 2015. The total number reached 5,108 analyses.

In the normal exposure situations, including cases of small incidents that can be kept under control, the internal doses observed are all below the recording level [2, 6].

The operating procedure established for the activities in the facility greatly contributes to the decreasing of the internal dose of workers. During the routine activities, the group of workers in the production laboratory has very low probability of radionuclides intake.

The other group which performs activities in the controlled area, to load the hot cell with radioactive material to be processed and also to withdraw the radiopharmaceutical products, has higher probability of internal contamination. In these processes, workers use personal protective equipment to minimize the intake of radionuclides.

There are also the maintenance operations such as repair, replacement of components and assemblies of specific systems within the production cells. The maintenances procedures are classified into preventive and corrective operations.

The interventions are emergency operations and the procedures are determined according to each situation.

During normal operation of the facility, most of internal monitoring results remained below the detection level of the measurement system in question, except in small events where the intake did not result in doses above the recording level. In this aspect the training of workers is critical to decrease the internal dose.
For preventive and corrective maintenance procedures, the results of monitoring also remained below the recording level. In these operations the risks involved to the incorporation of radionuclides are higher, however the activities are planned and the workers adequately protected before start the tasks.

In case of incidents or abnormal situations the data presented in Fig. 3 show the doses distribution according to the reference levels. The left column in Fig. 3 shows the results

lower than the recording level and the right column the values higher than the recording level but lower than the investigation level. According to the Brazilian regulatory position [2], the recording level is 0.20 mSv per month and the investigation level is established as 1.0 mSv per month or 6.0 mSv in a year. One exception occurred in 2010 where one worker received the dose of 8.1 mSv in a year as a result of single intake of radionuclides.

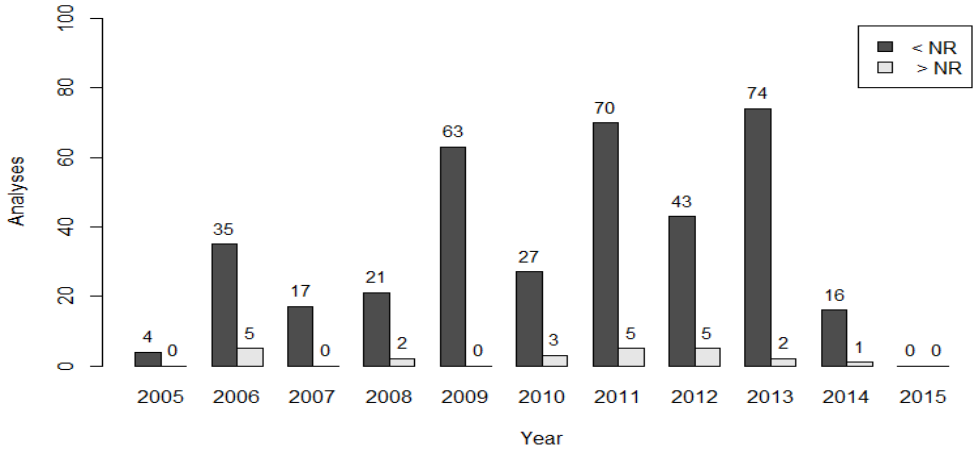

Figure 3: Results of monitoring data above the detection limit of the measurement system. The left column shows the results lower than the recording level (<NR) and the right column for values higher than this level (>NR), for each year.

The Fig. 4 show the main radionuclides which has contributed with intake values higher than the recording level. The ^{131}I appear more frequently and then followed by ^{99}Mo. These are the two radionuclides with major production frequency and also in activity. The others radionuclides as ^{123}I, ^{67}Ga, ^{201}Tl, ^{18}F, e ^{153}Sm have presented measurement values below the detection limit or values below the register level.

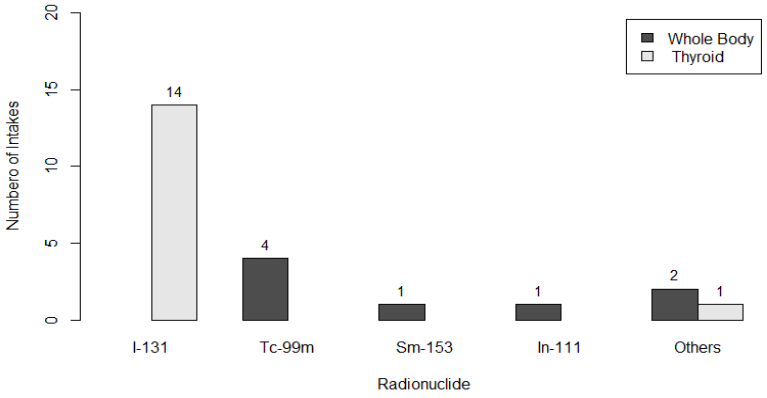

Figure 4: Main radionuclides which monitoring results are higher than the recording level.

4. CONCLUSIONS

The analysis of internal monitoring data of the workers at the radiopharmaceutical production plant of IPEN, in the course of 2005 to 2015, has shown good practice and the operational improvements introduced continuously in the facility has contributed to the dose optimization. It is observed that the planning of preventive or corrective activities is fundamental to minimize the internal contamination of occupationally exposed individuals. These actions have contributed to the maintenance of safety level even though the production of radiopharmaceuticals has increased during this period.

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