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ASSESSMENT OF THE RADIOLOGICAL CONTROL AT THE IPEN RADIOISOTOPE PRODUCTION FACILITY

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ABSTRACT

The main objective of this work is to evaluate the 2013 annual radiological control results in the radiopharmaceuticals areas of the Nuclear and Energy Research Institute, IPEN/SP, and the environmental radiological impact, resulting from the practices there performed. The current evaluation was performed through the analysis of the results obtained from occupational and environmental monitoring with air samplers and TL dosimeters. All monitoring results were compared with the limits established by national standards. The radionuclides detected by air sampling (in charcoal and paper filters) at the workplace during radioisotope production were ^{131}I, ^{99m}Tc and ^{99}Mo, with activities concentrations values below the annual limits values. For the radioactive gaseous releases (Bq/m^3), the activities concentrations also remained below the maximum permissible values, excepting to ^{125}I release due to an unusual event occurred in a researcher laboratory, but the radiological impact to environmental was no significant. The occupational monitoring assessment was confirmed by the Environmental Radiological Monitoring Program results with air samplers and TL dosimeters. The mean annual background radiation at IPEN in 2013, according to the Environmental Radiological Monitoring Program results was 1.06 mSv. y^{-1}, below the ICRP 103 recommended limit of 20 mSv.y^{-1} for workers.

1. INTRODUCTION

The use of radioisotopes in medicine is, one of the most important social applications of Nuclear Energy and IPEN (Nuclear and Energy Research Institute, São Paulo), is recognized as a national leader institution in research and development in the radiopharmaceutical area. Currently, more than 30 products available for medical uses are listed in the IPEN products and services catalogue. The production of IPEN Radiopharmaceuticals Center (CR) is divided in 3 different areas: Radioisotopes (^{99m}Tc generators and Primary Radioisotopes as ^{131}I), Labelled Compounds (^{131}I and ^{18}F) for diagnosis (PET and SPECT) and for therapy and Lyophilized Kits for labelling with ^{99m}Tc. IPEN has a rigorous program of radiological control for the radiological safety of IPEN workers and general public, through radiation protection programs in accordance with national and international standards.

Radiological monitoring of a radioactive facility requires the use of various techniques for determining the radiological parameters, associated either to environmental contamination, surface contamination or radiation levels. In general, it is desired to use the monitoring techniques which have advantages in terms of time, cost or easiness of handling while at the same time are sensitive enough.

The main objective of radiological protection is to provide an adequate level of protection for the workers, general public and environment, so that the society exposures must be limited to risks considered acceptable. This study aims to evaluate the existing exposure situations in at radiopharmaceutical facility of IPEN/SP due their practices. This work address the radiological control techniques used at workplace and environmental monitoring with the objective of estimate the resultant doses of facility's practices (Radioisotopes Production) and compare the obtained results with the established values by the national standard [1, 2].

1.1 Radiation Level Monitoring

According the ICRP-103 Publication [3], a radiological control program with good success in any facility or operation contains many parameters / indicators that are used to monitoring the workplace and reduce the radiation exposure.

The monitoring of air's radioactivity is carried out to:

(a) Detect and quantify the radioactive material concentration in the air,
(b) Limit and avoid the internal exposure,
(c) Provide a effectiveness indication of engineering controls and appropriate work practices to the prevention of dispersion and contamination and
(d) Support the choosing of the proper protective equipment.

The monitoring of workplace radiation level included the actions of general areas and areas where there is the contact with potential radiation sources.

Discharges of radioactivity material in environment due the operations of a practice

The radiological air monitoring allows to estimate the potential dose received by the population due the inhalation. The air constitutes the primary pathway of transference of radioactive effluents to the environment.

2. METHODOLOGY

2.1 Area Monitoring to Detect External Radiation in the Workplace

The routine monitoring is done by monitors at the area subject to gamma radiation. A total of 18 points are continuing monitored by fixed detectors Geiger Mueller and 11 points are monitored by thermoluminescent dosimeters, TLD ($CaSo_4$:Dy), located in select areas, with frequency of trimestral sampling.

2.2. Surface Monitoring

The surface contamination was assessed by indirect methods, using a smearing test followed by high-resolution gamma-ray spectrometry.

2.1. Air Monitoring - Indoor

The monitoring is done by monitors of the air using indirect methods and counting with high purity germanium semiconductor detector. These air samplers were located at workplace where there was probability of the air contamination occurrence.

2.3 Environment Radiological Control - Outdoor

The environment radiological control to the radiopharmaceutical facility is done as established in Environmental Radiological Monitoring Program of IPEN, (PMRA 2013) [4]. The direct radiation in the environment was determined by measurements with TL dosimeters, with quarterly frequency.

To the determination of emitting gamma radionuclides were analyzed in paper filters and charcoal filters collected fortnightly of the air samplers localized at Radiopharmaceutical Center´s parking, CR. The measurement allowed the identification of short half-life radionuclides, as ^{67}Ga (3.26 days) and ^{131}I (8 days) [4].

The gamma radionuclides emitters were determined by high resolution gamma-ray spectrometry.

3. RESULTS

3.1. Area Monitoring

The results of area monitoring, to external radiation, carried out in 2013 with TL dosimeters, totalized 11 points. Of these, 5 points showed mean weekly values higher than admissible maximum values of 400 µSv per week [1]. The higher dose rates were found out in points where is located the technetium-99m generator production and where there is an excess of packing, at CR´s parking, for the radioactive materials shipment. Actions of radiological protection are adopted as: workers' awareness to avoid these radiation exposure points, improvements of infrastructure, such as shielding, and avoiding the accumulation of material.

3.2. Air Monitoring

The detected radionuclides were ^{131}I, ^{125}I, ^{99m}Tc and ^{99}Mo. The emissions of ^{131}I and ^{99m}Tc were resulted of little leakages at the production cells. The ^{99}Mo was detected in filter surface, indicating particulate material. The concentration values (Bq/m^3) of these radionuclides, except to the ^{125}I, are above than the admissible maximum values established by the national standard [1, 2] and summarized in Table 1.

An incident with ^{125}I was detected in one of the research laboratories, which caused an air contamination equivalent to 20 times of the maximum established value. The area was interdicted by the radioprotection team and after the implementation of radiological protection actions the place was released coming back to normality.

Table 1. Admissible maximum values of concentration in activity (Bq/m^3) [2]

Detected radionuclides	Concentration in activity (Bq/m^3)
^{131}I	757
^{125}I	1142
^{99m}Tc	287356
^{99}Mo	7575

3.3. Discharges of Radioactive Material in Environment due the Operations -Indoor

The detected radionuclides at charcoal cartridge filter and paper filter of the chimneys from atmospheric liberations, it means, from discharges of gaseous radioactive effluents to environment, due the practices of the radiopharmaceutical facility, were ^{123}I, ^{131}I e ^{18}F. The important contribution of ^{131}I was observed in the total discharges, representing virtually the totality of the atmospheric discharges. The mean annual value of concentration in activity (Bq/m^3) for the ^{131}I, obtained by chimneys' filters analysis, was 1.76 Bq/m^3. This value is below the dispense level for gaseous waste of 3.7 Bq/m^3, established by the standard CNEN NN 8.01[6].

3.4. Discharges of Radioactive Material from Gaseous Effluents into Atmosphere Outdoor

3.4.1. Gamma spectrometry in paper filter

The concentrations of ^{67}Ga in paper filter determined by the air sampling are showed in Fig. 1. The concentration values found out in paper filter, for 2013, varied from 0.23 to 0.97 mBq/m^3. The concentration values reported are bellow than the established limits by the national standard.

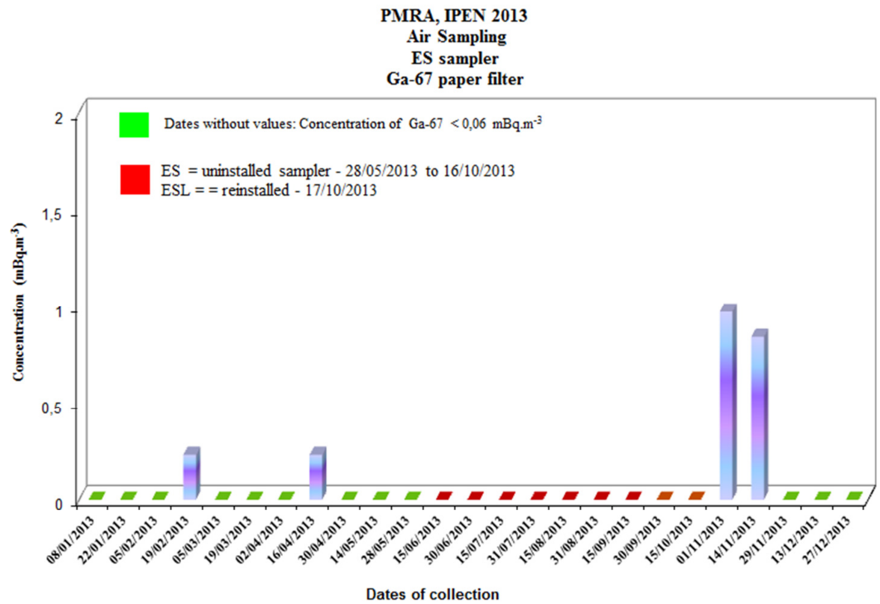

Figure 1. Concentration of ^{67}Ga in paper filter of air sampler located at CR's parking, IPEN, 2013.

The concentrations of ^{131}I in paper filter determined by the air sampling are showed in Fig. 2. The concentration values found out to the year of 2013 varied from 0.04 to 0.07 mBq/m^3. The concentration values reported are bellow than the established limits by the national standard.

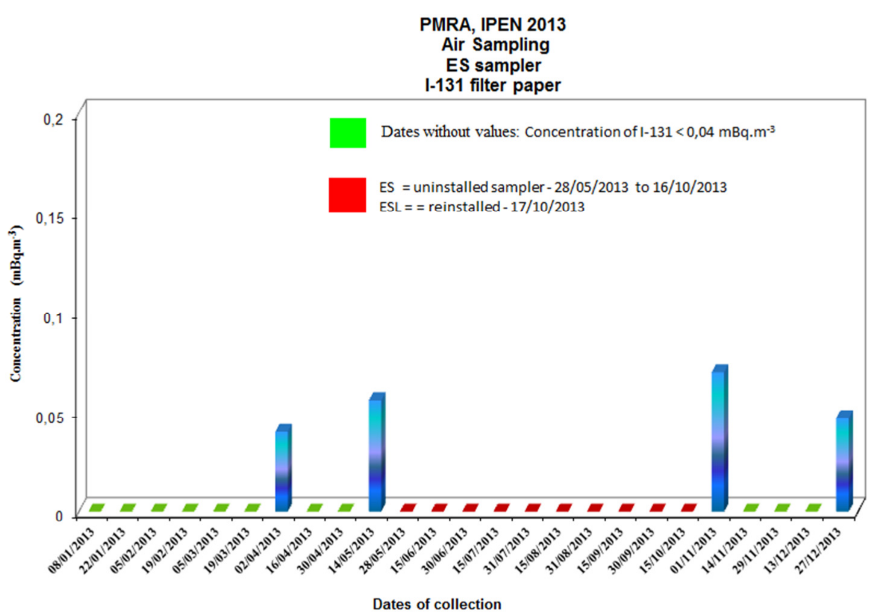

Figure 2. Concentration of ^{131}I in paper filter of the air sampler located at CR's parking, IPEN, 2013.

3.4.2. Gamma spectrometry in charcoal filter

The concentrations of ^{131}I in charcoal filter determined by the air sampler are showed in Fig. 3. The concentrations found out to the year of 2013 varied from 10 to 103 $mBq/m^{3.}$ The concentration values reported are bellow than the established limits by the national standard.

According to the standard CNEN NN 8.01 [6], for the elimination of radioactive gaseous waste, the admissible maximum concentration for the nuclide ^{131}I is 3.7 Bq/m^3.

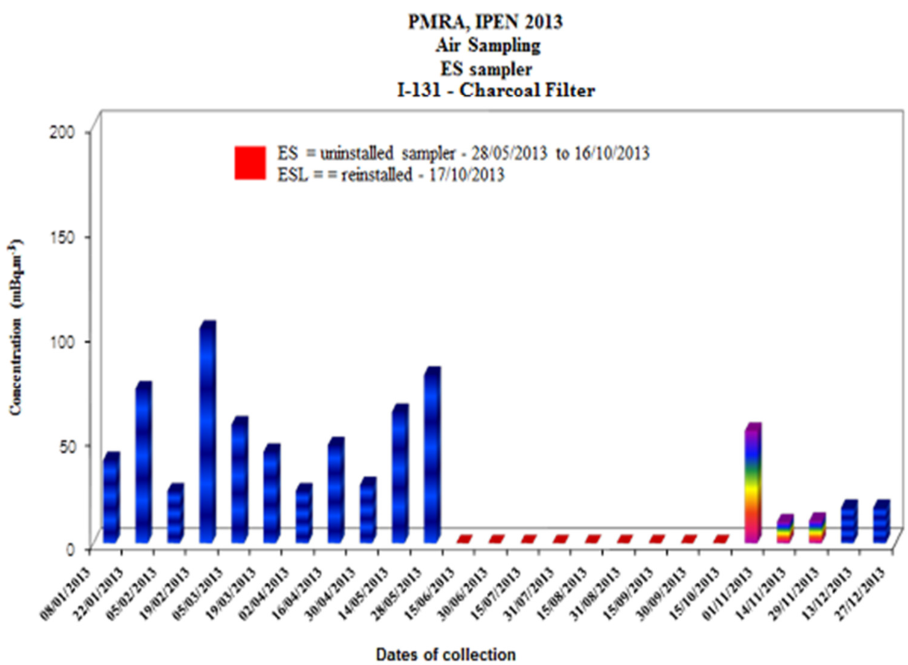

Figure 3. Concentration of ^{131}I in charcoal filter of the air sampler located at CR's parking, IPEN, 2013.

3. CONCLUSIONS

The radiological control carried out in the year of 2013 at the radiopharmaceutical facility of IPEN by the continuous monitoring and confirmation by the environmental radiological monitoring shown to be effective. It was observed a worry about the continuous improvement of the areas monitoring, with periodic inspections, mainly in the areas subject to contamination, and with the control of the IOE´s. The workers' training and a bigger awareness about the fulfillment of the operational procedures were aspects considered. Besides, the adoption of administrative procedures to the prevention and control allowed a significant reduction of the dose and potential contamination. In the monitoring period of

2013 was not observed any environmental impact due the facility's practices. This fact was confirmed by the mean annual value of the background radiation at IPEN of 1.06 mSv. y^{-1}.

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