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PARTE I

**Presentaciones y trabajos expuestos
en Congresos, Seminarios,
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Considerations on Potential Regulatory Actions for Radiation Protection in Radiotherapy: Monitoring Unwanted Radiation Exposure

González, A.J.

Considerations on Potential Regulatory Actions for Radiation Protection in Radiotherapy: Monitoring Unwanted Radiation Exposure

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Abstract: The objective of this paper is to present a discussion document on potential regulatory actions for monitoring adventitious unwanted radiation exposure in radiotherapy. That document was jointly prepared by the Argentine Nuclear Regulatory Authority (Autoridad Regulatoria Nuclear, ARN) and the International Atomic Energy Agency [IAEA]. The document introduces, describes and discusses the concepts of *unwanted radiation exposures in radiotherapy* (URERs), *unwanted doses in radiotherapy* (UDRs), *proxies* of UDRs, and *prospective increase of primary malignancies attributable to radiotherapy* (PIPMAR). It is concluded that it seems to be desirable that regulators with competence in the radiation protection of patients investigate further the issue of PIPMARs. For the purpose of controlling properly radiation protection of patients undergoing radiotherapy, particularly the requirements of justification of individual radiotherapy and optimization of the radiation protection of the individual patient, it is highly convenient for regulatory authorities that URERs be assessed and their UDRs be monitored and registered. Therefore, regulatory authorities should consider exploring regulatory actions for requiring monitoring and registering of URERs and their UDRs. Several techniques and proxies are available for this purpose.

KEYWORDS: *Radiation Protection of Patients; Radiotherapy; Adventitious Radiation Exposure.*

1. INTRODUCTION

The objective of this paper is presenting a discussion *document* (hereinafter referred to as the *document*) suggesting potential regulatory actions for monitoring adventitious unwanted radiation exposure in radiotherapy.

On 18 September 2015, the Argentine Nuclear Regulatory Authority (Autoridad Regulatoria Nuclear, ARN) and the Secretariat of the International Atomic Energy Agency (IAEA) agreed on '*Practical Arrangements*' setting forth the framework for non-exclusive cooperation between the Parties in the area of radiation safety and monitoring. A relevant activity agreed to be pursued under the '*Practical Arrangements*' was the '*development of regulatory guidance on radiological protection in radiotherapy, addressing in particular the potential increase in the risk of second cancers*'.

On August 05, 2017, ARN and the OIEA finalized and published a jointly prepared document under the title '*Considerations on potential regulatory actions for radiation protection in radiotherapy: monitoring unwanted radiation exposure in radiotherapy*' [1], clearly indicating that it was just a discussion document.

2. BASIC CONCEPTS

Four main concepts are used in the document, as follows:

2.1. Unwanted radiation exposures in radiotherapy

Unwanted radiation exposures in radiotherapy (URERs) are radiation exposures of a patient undergoing radiotherapy that are adventitious exposures; namely, URERs are neither wished nor desired but are unavoidably and unintentionally incurred during radiotherapy procedures.

2.2. Unwanted doses in radiotherapy

Unwanted doses in radiotherapy (UDRs) are the adventitious doses due to URERs incurred by patients undergoing radiotherapy. UDRs are additional to the prescribed radiotherapy doses to the prescribed volume, which can be incurred in any part of the body. UDRs can be monitored and recorded, either by measurement or estimation, through dosimetric quantities or suitable *proxies*.

2.3. Proxies of UDRs

The quantification of UDRs often means the measurement of *proxies*, i.e. substitutes. Proxies of UDRs are measurable quantities substituting a UDR that cannot be measured directly. Proxies can be physical quantities and also biological quantities.

2.4. Prospective increase of primary malignancies attributable to radiotherapy

The definition of *prospective increase of primary malignancies attributable to radiotherapy* (PIPMARs) is subtly more precise than what usually is indistinctly termed ‘second cancers’, ‘secondary cancers’ or ‘second primary cancers’, and it is identified with the acronym SPC [2]. The various SPC’s definitions being used are ambiguous and could be construed as comprising only cancers being developed in the primary treatment field. PIPMARs are defined as comprising all unwanted adventitious malignant sequelae of radiotherapy, which are remaining latent and manifest after the treatments. PIPMARs do not only include solid cancers but also leukaemia, i.e. include all malignancies. PIPMARs are not metastases of the original malignancy, but primary malignancies. PIPMARs are not limited to second primary malignancies but to the entire sequence of metastases that could originate from them.

3. PIPMARs AND RADIATION PROTECTION

In the frame of the international radiation protection system, PIPMARs are correlated to a radiation detriment attributable to radiotherapy. PIPMARs therefore become a conjectural expectation of radiation harm that is conceptually and retrospectively assignable to radiotherapy.

While the US National Council on Radiation Protection & Measurements warned that there was a wealth of knowledge on the risk of SPC following radiation therapy indicating clear increases following high-dose and scatter-dose radiation, one of the first international call of attention on the issue of PIPMARs occurred at the International Conference on Radiological Protection of Patients in Diagnostic and Interventional Radiology, Nuclear Medicine and Radiotherapy [3], which took place in Malaga, Spain, in 2001, where it was declared that ‘radiation to normal tissue has a number of possible negative sequelae including the possible induction of secondary cancers’. This Conference triggered an international response aimed at the protection of patients.

The Malaga Conference was followed by the International Conference on Radiation Protection in Medicine: Setting the Scene for the Next Decade[4], which took place in Bonn, Germany in 2012, where it was declared that ‘even with high precision photon radiotherapy, a large volume of surrounding normal tissues may be exposed to low levels of dose’.

The growing interest for the issue of PIPMARs has recently arrived to the highest international level: the United Nations General Assembly (UNGA). On 13 December 2019, UNGA adopted a Resolution [5] in which it ‘...supports the intentions and plans of [the United Nations Scientific Committee on the Effects of Atomic Radiation] UNSCEAR for conducting its programme of work

of scientific review and assessment on behalf of the General Assembly, in particular.....*its assessments of second primary cancer after radiotherapy...*

The interest on the radiation protection of patients undergoing radiotherapy is enhanced by the size of the population of concern to be affected by PIPMAR. The general incidence of malignancies is known to be high: in the order of quarter of the population may suffer a malignancy. The fraction of patients suffering malignancies that are treated with radiotherapy have increase enormously. In the developed world it may reach around half of sufferers. Finally, the expected fraction of survivors has also been steadily increasing. With the fraction of cures increasing year after year, the cohort subjected to PIPMARs may comprehend millions of people!

Obviously many confounding factors may affect this prospective cohort, including lifestyle factors, such as smoking habits and diet, genetic susceptibility; and, proneness to radiation-induced malignancies or radio-susceptibility. But in any case, the size of a cohort is such that its radiation protection can not be ignored.

4. REGULATION

Given the existence of PIPMARs and the size of the prospective cohort of sufferers, regulatory authorities with responsibilities of radiation protection face a number of ethical dilemmas. Should regulatory authorities be concerned about PIPMARs?. Should regulatory authorities be passive vis-à-vis PIPMARs? Should they engage in promoting regulatory policies that could benefit the affected patients? What actions might they take?

An ethical outcome could be straightforward: recognizing the existence of UREs and their potentiality for PIPMARs, undertake regulatory actions requiring that UDRs attributable to UREs be properly monitored and recorded either directly or through UDRs' proxies. This is the epilogue suggestion of this document!

4.1 Evolution of the International Regulation

Recommending an international radiation protection paradigm is the remit of the International Commission on Radiological Protection (ICRP), which in its recommendations indicate that 'the work of ICRP helps to prevent cancer and other diseases and effects associated with exposure to ionising radiation'. A specific ICRP body, ICRP Committee 3, is concerned with protection of persons and unborn children when ionising radiation is used for medical diagnosis, therapy, or for biomedical research. Notwithstanding, the response of ICRP to the issue of PIPMAR has been somehow limited. While the issue is implicitly mentioned in ICRP recommendations, for instance in recommendations on radiological protection in ion beam radiotherapy, no specific ICRP recommendations have been developed on how to deal with PIPMARs, even in the ICRP latest recommendations [6].

The IAEA is the only international intergovernmental organization with specific statutory functions in radiation protection. In response to this mandate, it issued radiation protection and safety measures in March 1960 [7], and subsequently approved basic safety standards (BSS) for radiation protection in June 1962 [8]. These were the first international radiation protection standards. A revised version of the BSS was published in 1967 [9]. It is to be noted that all these earlier international standards ignored the protection of patients.[10].

The third revision of the BSS was published by the IAEA as the 1982 Edition of Safety Series No. 9 [11] and was jointly sponsored by *inter alia* the WHO. These standards required that medical exposure should be subject to the radiation protection requirements of justification [of medical

procedures] and optimization [of protection during the procedures] [12], thus becoming the **first international standards involving requirements for the protection of patients**.

A substantial revision of the BSS was approved in 1996. The ‘International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources’ were issued as IAEA Safety Standards 115 [13], with a wide co-sponsorship of international organizations including WHO. They included for the first time a set of comprehensive international radiation protection requirements for ‘medical exposures’. The requirements included *inter alia* responsibilities, justification of medical exposures, optimization of protection for medical exposures and explicit requirements for therapeutic exposure.

The latest revision of the international standards is the ‘Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards’ [14]. They are supported by Fundamental Safety Principles [15], which are cosponsored by all relevant intergovernmental organizations: the European Atomic Energy Community (Euratom), the Food and Agriculture Organization of the United Nations (FAO), the International Labour Organization (ILO), the International Maritime Organization (IMO), the OECD Nuclear Energy Agency (OECD/NEA), the Pan American Health Organization (PAHO), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO). They emphasize and expand the international requirements for the protection of patients, including requirement for the protection of patients undergoing radiotherapy.

4.2 Relevant International and Intergovernmental Radiation Protection Requirements

In short, the international and intergovernmental radiation protection requirements requires that medical exposures be justified and that radiation protection options be optimized and any of these requirements involves monitoring of the situation.

4.2.1. *Justification of medical exposures in radiotherapy*

In relation to the purpose of the suggestions in the document, the requirement of justification can be defined as follows: Any decision to undertake radiotherapy in a patient, which would alter the radiation exposure of the patient, should do more good than harm. The ICRP has suggested that medical exposures would call for a different and more detailed approach to the process of justification. The principal aim of medical exposures, including radiotherapy, is to do more good than harm to the patient.

The requirement of justification applies at three levels in radiotherapy. At the first level, the use of radiation in medicine has to be accepted as doing more good than harm. At the second level, a specified radiotherapy procedure with a specified objective shall be defined and justified with the aim of judging whether the radiotherapy procedure will bring more good than harm. At the third level, the application of the procedure to an individual patient should be justified, i.e., the particular application should be judged to do more good than harm to the individual patient. This third level is the relevant level for the purposes of the suggestions in the document.

It follows that it is essential for the regulator to be able to estimate URERs and their UDRs in order to enforce compliance with the justification requirement.

4.2.2. *Optimization of radiation protection in radiotherapy*

The optimization of radiation protection applied to radiotherapy requires that the protection of the patients should be the best under the prevailing circumstances, namely that URERs and their UDRs

should be kept as low as reasonably achievable, all factors being taken into account. Therefore, optimization involves not only delivering the prescribed dose to the tumour, but also planning the protection of healthy tissues outside the target volume and thus protection against PIPMAR.

The international standards establish specific design and operational requirements for optimization, as follows:

- In relation to design considerations the standards require that registrants and licensees, in cooperation with suppliers, shall ensure that radiotherapy equipment, and software that could influence the delivery of medical exposure is used only if it conforms to the applicable standards of the International Electrotechnical Commission and the International Organization for Standardization or to national standards adopted by the regulatory body.
- In relation to operational considerations, the standards establish that for therapeutic radiological procedures, the radiological medical practitioner, in cooperation with the medical physicist and the medical radiation technologist, shall ensure that for each patient the exposure of volumes other than the planning target volume is kept as low as reasonably achievable consistent with delivery of the prescribed dose to the planning target volume within the required tolerances.

It follows that it is essential for the regulator to be able to estimate URERs and their UDRs. in order to enforce compliance with the optimization principle.

4.2.3. Monitoring

The regulatory need to be acquainted with URERs and their UDRs implicitly bring to the regulatory need of requiring monitoring of URERs, namely the measurement of UDRs or their proxies related to the assessment of exposure to radiation and the interpretation of the results.

The superseded international radiation protection standards, issued in 1996 notably required that ‘when competent authorities review existing [medical] examinations or treatments involving exposures to radiation, they should take into account the somatic and genetic detriment of such exposures’ [16]. *Mutatis mutandi*, this statement could be considered the first international requirement for monitoring exposure in radiotherapy. Remarkably, those superseded standards also required that registrants and licensees shall ensure that ‘the patient be informed of possible risks’ [17].

However, these requirements were not repeated in the new international standards, perhaps because they were considered obvious. Notwithstanding, the new standards require programmes of quality assurance in radiotherapy including those for monitoring equipment [18].

The new standards require that calibrations of radiotherapy units be subject to independent verification prior to clinical use [19]. They also include specific requirements for the release of patients, such as that registrants and licensees shall ensure that there are arrangements in place to ensure appropriate radiation protection for members of the public and for family members before a patient is released following radionuclide therapy [20].

They moreover include requirements for recording, including the following: ‘for radiation therapy, a description of the planning target volume, the dose to the centre of the planning target volume, and the maximum and minimum doses delivered to the planning target volume, or equivalent alternative information on doses to the planning target volume, the doses to relevant organs as selected by the radiological medical practitioner, the dose fractionation, and the overall treatment time’ [21].

Notwithstanding these current international radiation protection requirements for radiotherapy, it should be underlined that there is an absence of specific and unambiguous requirements on the monitoring or even gross assessment of URERs and their UDRs and their proxies.

In summary, it appears to be essential that regulators be acquainted with URERs and know the attributable UDRs, either directly or through proxies, in order to enforce compliance with the international and intergovernmental requirements of justification of radiotherapy for individual patients and optimization of protection of the patient in order to ensure that such protection be the best under the prevailing circumstances.

5. CONCLUSIONS

From the document summarized here, it can be concluded that: it seems to be desirable that regulators with competence in the radiation protection of patients investigate further the issue of PIPMARs.

The current international standards require that radiotherapy procedures be generically justified. While such generic justification are expected to be carried out in conjunction with appropriate professional bodies and to be reviewed from time to time with account taken of advances in knowledge and technological developments, the relevant regulatory authority is entrusted with the regulatory control of justification. It seems that in order to be able to control properly such generic justifications of specific radiotherapy procedures, there would be convenient for the authorities to benefit from a wide knowledge of URERs and their UDRs. Systematic monitoring and registering of URERs and their UDRs would be a helpful tool for controlling the justification of prospective procedures.

The current international standards also require that the radiation protection of patients undergoing radiotherapy be optimized. While approaches to optimization in radiotherapy are expected to be evaluated in conjunction with appropriate professional bodies, the relevant regulatory authority is entrusted with the regulatory control of optimization. Optimization could be interpreted as reducing URERs and their UDRs to a level that is as low as reasonably achievable under the prevailing circumstances, taking account that radiotherapy procedures are expected to deliver prescribed therapeutic doses. Again, systematic monitoring and registering of URERs and their UDRs would be a helpful tool for controlling the optimization of protection in justified radiotherapy procedures.

It appears therefore that, for the purpose of controlling properly radiation protection of patients undergoing radiotherapy, it is highly convenient for regulatory authorities that URERs and their UDRs be monitored and registered and that regulatory actions be explored for requiring monitoring and registering of URERs and their UDRs. Several techniques and proxies are available for this purpose, from physical measurements followed by sophisticated computerized assessment programmes to the relatively inexpensive and widely available biological dosimetry.

It is consequently suggested that the IAEA in consultation with regulatory authorities of its Member States explore the possibility to establish international guidance for assisting national authorities in establishing requirements for monitoring and recording URERs and their UDRs.

6. CAVEAT

The sole intention of this document is to suggest exploring the feasibility of regulatory requirements for monitoring and registering of URERs and their UDRs, for *inter alia* facilitating the implementation of the already established regulatory requirements of justification and optimization.

In particular, the suggestions herein should not be construed as recommendations for, or implications on, any potential actions that health authorities might consider in relation to PIPMARs or as taking a position on the issue of individual health assessment of asymptomatic persons.

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Emerging Challenges for the International System of Radiation Protection Quantities and Units

González, A.J.

Emerging Challenges for the International System of Radiation Protection Quantities and Units

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Abstract: This paper submits a diagnosis of potential difficulties with the international system of radiation protection quantities and units and describe potential successes and challenges for addressing possible difficulties with the system. It summarizes critiques to the system, including lessons compiled in the aftermath of the Fukushima accident and reflections from professionals in metrology. It also addresses the reaction of ICRP and ICRU for addressing those challenges. It suggests that the proposed revisions, while welcomed, could be insufficient. The system seems to present some epistemological challenges that need to be addressed. They include that a common quantity and unit are used for: distinct outcomes, such as clinically observable, or statistically observable or biologically plausible radiation effects; different concepts, such as that at high doses, effects are attributed and at low doses risk are inferred; diverse outputs, such as diagnosis of individual effect, estimates of collective incidences, or judgment of risk; attesting on health outcomes through formal evidence by radiopathologists, or radioepidemiologists or radioprotectionists; and, for imputing individual harm or collective harm (class actions) or presumptions of risk. Moreover, the same family of dosimetric quantities (without any provisos) are used as: intensive quantities, and extensive quantities. This does not happen in other areas of science requiring measurability. Finally, an important shortcoming of the current system is addressed: the current quantities and units seems to be unhelpful for public information and communication; they should fail to convey, in a fully and easily understandable and credible manner, radiation effects and risks therefore facilitating psychological associated to the misunderstanding of radiation. It is concluded that the relevant international and intergovernmental organizations should consider improving the current international system of quantities and units not only in its obvious shortcomings but also in its epistemological deficiencies and its communicational weaknesses.

KEYWORDS: *radiation quantities; radiation units; radiation safety standards; ICRP ; ICRU ; UNSCEAR; IAEA.*

1. INTRODUCTION

The international system of quantities units for radiation protection is one of the most significant international and intergovernmental successes. It is: universal and consensual; founded in internationally accepted science; based on a universal paradigm recommended by: the International Commission for Radiological Protection (ICRP) and the International Commission for Radiation Units and Measures (ICRU); adopted: Bureau International des Poids et Mesures (BIPM); and established in the international safety standards of all relevant intergovernmental organizations, developed under the aegis of the International Atomic Energy Agency (IAEA). Notwithstanding its success, after almost a century of good service, the system may need some review and eventually some revision.

The objectives of this paper are submitting a diagnosis of potential difficulties with the system and describing potential successes and challenges for addressing remaining problems.

2. CRITIQUE

2.1. Lessons from Fukushima

Following the nuclear reactor accident at the Fukushima Daiichi nuclear power plant in Japan, the ICRP convened a Task Group to compile lessons learned from, with respect to the ICRP system of radiological protection. These included issues with the international system of quantities and units being used by ICRP. In a memorandum the members of the task group express their personal views on issues arising during and after the accident. While the affected people were largely protected against radiation exposure and no one incurred a lethal dose of radiation (or a dose sufficiently large to cause radiation sickness), many radiological protection questions were raised. One issue identified was that the system of radiation protection quantities and units caused considerable confusion and communication problems.[1]

The differences between the quantities were not well understood even by high educational level audiences; for example, differences among absorbed dose, equivalent dose and effective dose. The distinction between the radiation protection quantities and the operational quantities was even more difficult to understand; for example, the equivalent dose *vis-à-vis* the dose equivalent, which in addition presented a grammatical problem for translatability. The practice of using a unique unit for different quantities, without specifying the quantity, increased confusion and misunderstanding; for instance, the use of a common unit (sievert or rem) for equivalent dose incurred by an organ, for the effective dose incurred by the body, and for dose equivalent of a radiation field..

It was not clear for member of the public, and for their representatives, why so many different quantities and units were needed to protect people against radiation.

The Task Group concluded that the radiation protection community has an ethical duty to learn from Fukushima's lessons and to resolve the identified challenges, one of which related with the international system of radiation protection quantities and units. The Task Group advised that, before another major accident occurs, confusions on the international system of radiation protection quantities and units must be resolved.

2.2. Appraisal from metrology

On 23-25 November 2014, took place in Rio de Janeiro, Brazil, the First Brazilian Congress on Ionizing Radiation Metrology (Primeiro Congresso Brasileiro de Metrologia da Radiação Ionizante, CBMRI).[2] The main purpose was to review various concepts, fundamental topics and methods related to the primary or secondary measurements of ionizing radiation. Following the approach proposed by the BIPM Comité Consultatif pour les Etalons de Mesures des Rayonnements Ionisants, the CBMRI was devoted to three different aspects of metrology, namely: radionuclides and radioactivity; X-rays, gamma, electron and charged particles; and, neutron metrology. It also addressed approaches to traceability, primary standard (absolute) and secondary (relative), assessment of uncertainties, nuclear instrumentation, and laboratory infrastructure. But one major topic was a critical review of the international system of quantities and units.

There an extensive discussion took place on the desirability of improvements in the system of radiation protection quantities and units [3]. The global system of quantities and units was critically reviewed. It was recognized that the system has proved successful in helping radiation protection to become a globally uniform, consistent and coherent professional discipline. However, as it happen with any other successful development, it was found, the experience gained over time is showing that the system my benefit from some improvements. It was suggested that the time seems to be ripe for undertaking a deep review of the current system of quantities and units and suggest the necessary revisions to update it, by taking into account a number of lessons learned, particularly in the aftermath of nuclear accidents and in the protection of patients in the practices of radio-diagnosis, interventional radiology and radiotherapy.

Difficulties with the system were analysed and some feasible solutions were suggested. The system was found to be used successfully for more than 30 years in controlling occupational exposure and public exposure in normal situations, prospectively in the design of facilities and planning of operations and retrospectively for demonstrating compliance with regulations. However, it was found, the use has also demonstrated great difficulties in communicating radiological information to non-specialized experts and to the public. These difficulties in understanding the units and quantities appeared to be a consequence of the complexity of the system which uses more than one quantity and combines physical exposure data with scientific data on radiation risk for organs and tissues.

Moreover, it was considered that, although the system and the quantities have shown to be well suited for occupational radiological protection, there is less suited for use in the public domain where communication with non-experts is required, particularly in emergency situations.

The number of difficulties found included: the differences between the quantities (e.g. effective dose and equivalent dose and absorbed dose) are not well explained and are not well understood even by educated audiences; the distinction between the quantities used in the radiological protection system (e.g. equivalent dose and effective dose) and the operational quantities used for radiation measurement (the dose equivalent quantities, e.g. personal dose equivalent) is even more difficult to understand; the use of the same unit (i.e. Sievert) for the quantities equivalent dose of an organ and the effective dose over the body, without specifying the quantity, and for the operational quantity dose equivalent, enhances confusion and misunderstanding; and, in sum, it was confirmed that many people not understand why there are so many different quantities.

It was moreover found particularly confusing that the different radiation protection quantities have a common unit, the Sievert. The problem becomes particularly evident when reporting thyroid doses to workers and the public from intakes of radioactive iodine. The equivalent dose is the relevant quantity for reporting organ doses but, if the dose is reported indicating only the unit, it can easily be confused with effective doses. The effective dose is a risk-related quantity for the whole body and can differ appreciably from the equivalent dose to an organ for the same person.

The discussion concluded that there were are a number of possibilities for improving the situation in the short term. For instance: avoiding the use of equivalent dose without specification of the organ or tissue concerned, e.g. a thyroid equivalent dose; and using the shorter and simpler term 'organ dose' for organ equivalent dose in communications, e.g. thyroid dose, which is already usual in many radiological protection practices. Another solution to minimize confusion is to always add the quantity when the unit Sievert is being used. Another solution would be to consider renaming the units, but this would require careful deliberation.

On important shortcoming confirmed was that the current system does not include simplifying quantities for the sole purpose of public information. Purists working in quantities and units would probably reject the idea. Simplification will always imply a loss in the scientific rigor that is essential in quantification. But, is not rigor already violated in the current system of protection quantities? In fact, it was concluded, the protection quantities do not comply with the essential requirements for quantities. A further simplification could be welcomed if this will make easier the serious problem of public communication.

It was also concluded that a system of public information quantities should be tailored to convey, in a fully and easily understandable and credible manner, radiation effects and risks. This would at least avoid the serious psychological effects that are associated to the misunderstanding of radiation

and its quantification. In fact, public distrust is generated when the authorities transmit information in a quantitative manner that is not understandable not only by the public at large but also to many experts.

Perhaps a system like this, it was suggested, could include simplified quantities to convey, for instance, the presence of radioactive substances in the environment including its temporal variation. The ideal would be to have few, or even an unique, quantity, summarizing in a simplified manner all the elements currently covered by activity, absorbed doses, weighting factors, temporal variation, etc.

It was concluded that it was difficult to answer if this possibility is really feasible. However, it is clear that it is feasible and desirable to study the possibility to develop a system of quantities for public communication.

In sum the discussion at CBMRI concluded that the quantities used for radiation protection purposes and for measurement purposes are somewhat sophisticated and their application requires professional knowledge. However, radiation protection practitioners are not alone in using these quantities, as emergency decision-makers—who do not necessarily know the details—rely on them for their choices of intervention and in the receiving end the public claim for simplicity in understanding. Misunderstandings about the quantities in the aftermath of an accident may lead to untoward difficulties, incorrect interpretations of potential consequences and incorrect decisions and after all serious psychological and social detriment for member of the public. Ways to improve and foster information exchange and education and to develop ‘easy-to-read’ material on the system of radiological protection quantities and units are sorely needed.

Recently, on november, 2020, the CBMRI 2020 took place virtually. The same problems were discussed again [4]. But this time the critique expanded to include the epistemological problems with the current system, an issue that will be discussed hereinafter.

3. ONGOING REVISIONS

Following the various critique on the system, the ICRP. Crated a task group (ICRP-Task Group 79), under ICRP Committee 2, on the use of effective dose as a risk related radiological protection quantity. The Task Group on Effective Dose is providing guidance on when the quantity ‘effective dose’ can be used and when it should not. ICRP indicated that experience has shown that ‘effective dose’, which has been defined and introduced by ICRP for risk management purposes, i.e. for risk limitation and optimization, is widely used in radiological protection and related fields beyond its original purpose, incorrectly in some cases. Useful guidance on restrictions on the use of the quantity has provided in the main ICRP recommendations. ICRP consider that this guidance needs to be further expanded, and proposals made for the control of exposures and risk management in situations where ‘effective dose’ should not be used. The ICRP recommendations on the use of effective dose as a radiological protection quantity are being presented [5]

Meanwhile, ICRU-Committee 26 is also addressing a revision of operational radiation protection quantities for external radiation. Concept and practical implications of the new definitions of ICRU and ICRP operational quantities for external radiation are being presented [6]. The changes proposed by the ICRP-TG79 include inter alia discontinuing the use of the *organ equivalent dose* (H_T in Sievert) and instead use the *organ absorbed dose* (D_T in Gray). The changes proposed by ICRU-Committee 26 includes: discontinuing the use of *ambient dose equivalent* ($H^*(d)$), *directional dose equivalent* ($H'(d, \Omega)$) and *personal dose equivalent* ($H_p(d)$), and replacing them with *ambient dose* (H^* in Sievert), *personal dose* (H_p in Sievert), *personal*

absorbed dose (D_p in Gray) and *directional absorbed dose* ($D'(\Omega)$ in Gray). These changes are welcomed but will might not resolve some fundamental epistemological and communicational challenges with radiation protection quantities and units, as it will be discussed hereinafter. The industry is reacting with some scepticism: the World Nuclear Association is presenting some views from radiation protection practitioners in the nuclear industry [7]

4. REMAINING EPISTEMOLOGICAL ISSUES

There are at least two epistemological anomalies in the current system. The first refer to the use of the same quantity and unit for addressing health effects attributable to radiation and inference of radiation risks. The second relate to the current confusion between intensive ad extensive quantities.

4.1. Common quantity and unit for attributing effects and for inferring risks

A fundamental epistemological problem with the current system is that the same quantity, the effective dose, and te same unit, the sievert, without any proviso, are used for assessing health effects that are attributable to radiation exposure and also for inferring conjectural radiation risks. Relatively recently, an international intergovernmental consensus on the attribution of provable radiation health effects vis-à-vis the inference of conjectured risk has been at achieved by the United Nations Scientific Committee of the United Nations on the Effects of Atomic Radiation (UNSCEAR) [8]. UNSCEAR is the international intergovernmental organization assigned by the United Nations General Assembly to be responsible for estimating the global levels and effects of radiation. In the exercise of his functions UNSCEAR has estimated the attribution of the effects on health and the inference of radiation risks. The UN General Assembly has unanimously welcomed with appreciation the scientific report of UNSCEAR on this issue [9]. The UNSCEAR estimates have been summarized by the United Nations Environment Program (UNEP) [10].The paradigm can be condensed in the dose-response relationship presented in Figure 1.

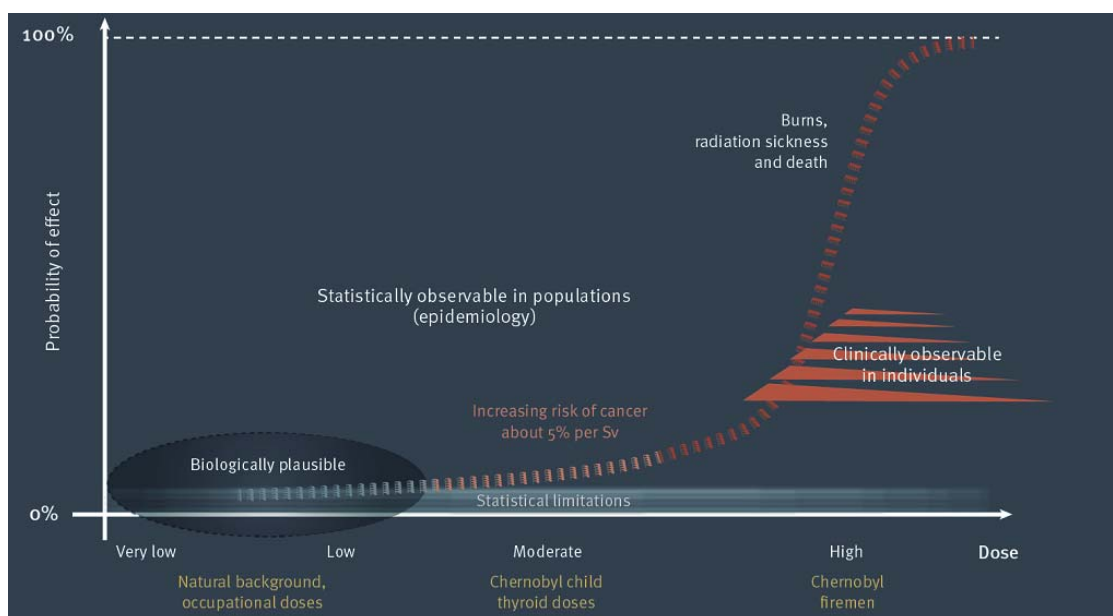


Figure 1: Relationship of radiation dose and probability of effects

The renewed UNSCEAR paradigm is subtly precise than the UNSCEAR's previous estimates [11]. The figure summarizes it by presenting a simplified relationship between effective doses incurred by people and the probability of occurrence of health effects. It clearly differentiates three zones: doses at which effects are clinically observable in individuals; doses at which effects are observable in populations throughout epidemiological studies; and doses where the effects are just biologically plausible. The abscissa indicates effective doses expressed as: 'high doses' (around a thousand of milliSievert); 'moderate doses' (around hundreds of milliSievert; 'low doses' (about tens of milliSievert); and, 'very low doses' (around the milliSievert). The ordinate expresses probabilities presented in percentages between 0% and 100%, where: 100%, corresponds to the certainty that the effect will occur; and, 0%, corresponds to the certainty that the effect will not occur. In the moderate, low and very low region they represent what ICRP termed detriment-adjusted nominal risk, defined as the probability of the occurrence of a stochastic effect, modified to allow for the different components of the detriment in order to express the severity of the consequence(s).

It is to be noted that, the probabilities estimated by UNSCEAR are of two distinguishable types:

- *frequentist probabilities*, which are in the medium and high dose area, based on the truthful and verifiable existence of radiation health effects, and can be described as the limit of the relative frequency of incidence of the effect in a series of certifiable epidemiological studies; and,
- *subjective probabilities* (also called "Bayesian"), which are in the low dose area, are expressed a possible expectation that radiation health effects might occur, and are quantified by a personal belief or expert's judgement, that is not substantiated by the frequency or propensity that the effects actually occur.

Both frequentist and subjective probabilities are mathematically compatible but epistemologically very different: the first is based on facts; the second is based on conjectures. This is a crucially important difference because UNSCEAR has highlighted the importance of distinguishing between: verified observations of health effects in exposed individuals and populations, which allow such effects to be unambiguously attributed to the exposure situations that generated them; and, theoretical projections of health effects, which occurrence is feasible but not verifiable –namely those projections only allowing some inferring of risks.

In simpler terms, the situation can be described as follows: the detriment-adjusted nominal risk for a nominal population is estimated to be around 5% per Sievert of effective dose; this number is mathematically equivalent to 0.005% per milliSievert of effective dose; however, the mathematically equal coefficients of 5% per Sievert and 0.005% per milliSievert are epistemologically very different because they describe different sciences, factual epidemiological evidence versus conjectural estimates.

Notwithstanding these fundamental epistemological differences, a common quantity, the effective dose, and a common unit the Sievert are used for both, the attribution of effects and the inference of risk. This implies using the same quantification approach for very disparate situations such as:

- distinct outcomes, such as what is clinically observable, or statistically observable or biologically plausible;
- different concepts, such as that at high doses, effects are attributed and at low doses risk are inferred;
- diverse outputs, such as diagnosis of individual effect, estimates of collective incidences, or judgment of risk;
- attesting on health outcomes by providing formal evidence by radiopathologists, radioepidemiologists and radioprotectionists; and, last but not least,
- for imputing individual harm or collective harm (class actions) or risk presumptions.

This is an epistemological anomaly of the system that would merit a deep discussion.

This important global agreement reached by UNSCEAR was reported in the literature [12], [13] but it is still far from being implemented in the regulatory practice. It is not currently used in the radiation protection standards of international intergovernmental regulations [14] and, consequently, in the vast corpus of nuclear safety regulations being established under the aegis of the IAEA with the co-sponsorship of all relevant intergovernmental organizations. The IAEA Commission on Safety Standards has been addressing the issue and a report is in preparation.

Thus, the use of the same quantification for the diverse epistemological situations of factual attribution of effects versus the conjectural inference of risk merits a deep discussion among the experts in radiation protection quantities and units.

4.2 Common quantity and unit for intensive and extensive quantities

An additional epistemological problem is that the same same family of dosimetric quantities (without any provisos) are used for expressing intensive quantities, and extensive quantities. This does not happen in other areas of science requiring quantification. The dose is an intensive quantity, namely a physical quantity whose value does not depend on the amount of matter for which it is measured, similarly to the quantity temperature. Conversely, the collective dose is an extensive quantity, namely a physical quantity whose value is proportional to the size of the system it describes or the amount in the system, similarly to the quantity energy. However, the same unit, the Sievert, is used by such diverse quantities, although qualified by the name 'man' or 'person' for the collective dose. This has cause serious problems of interpretation among experts and communication among the amateurs.

5. QUANTITIES, UNITS AND COMMUNICATION.

An important shortcoming of the current system is that the current quantities and units are not helpful for public information and communication. The quantities and units should be tailored to convey, in a fully and easily understandable and credible manner, radiation effects and risks. They should prevent the serious psychological effects that are associated to the misunderstanding of radiation. Public distrust is generated when the authorities transmit quantities that are not understandable not only by the public but also to many experts. A revision should facilitate to solve the problem of communication

6. CONCLUSIONS

The ongoing revision of the current international system of radiation protection quantities and units is needed and welcomed. However, it might not be sufficient. A deeper revision could provide an opportunity for making a distinction between the quantification of attributable radiation effects and the quantification of conjectural inferred risk, and, also for clearly differentiating intensive dosimetric quantities from extensive dosimetric quantities. A substantive revision could also be an opportunity for improving language and enhancing communication. It is suggested that the relevant international and intergovernmental organizations may use this opportunity to improve the current system of not only in its obvious shortcomings but also in its epistemological deficiencies and its communicational weaknesses.

7. ACKNOWLEDGEMENTS

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Radioactivity in Goods Supplied for Public Consumption or Use: Towards an Internationally Harmonized Regulatory Framework

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Radioactivity in Goods Supplied for Public Consumption or Use: Towards an Internationally Harmonized Regulatory Framework

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Abstract: The objective of this paper is to present a discussion document, jointly prepared by the Argentine Nuclear Regulatory Authority and the International Atomic Energy Agency, which provides suggestions for moving towards an internationally harmonized regulatory framework for controlling radioactivity in goods supplied for public consumption or use. Its concluding recommendations are: (1) the terms *commodities* and *consumer products* should be replaced by *consumer goods*, i.e. products supplied for public consumption or use; (2) the term *contamination* should be avoided when referring to consumer goods; (3) the quantity for regulating consumer goods should be the activity, and its derivatives; (4) consumer goods should be regulated, regardless of the origin of the radionuclides; (5) the amount of natural radionuclides in widely available consumer goods could serve as indicator of acceptable levels of radioactivity; (6) national frameworks should be coherent and consistent with consensual international guidance established by the governing bodies of relevant international intergovernmental organizations; (7) the regulation of consumer goods should neither be based on the exposure situation from which they are derived nor on the type of exposure being incurred; (8) the control criteria should take into account conflicting views on *edibility*; (9) activity levels in consumer goods that are considered safe for women and children should be used as the main criteria, based on consideration of a notional 'person' representative of those at higher risk; and (10) national systems for controlling consumer goods could be framed on the following criteria: (i) States should establish the levels of radioactivity under which consumer goods can be excluded from regulatory control, because such control is and (ii) Regulators should establish the levels of radioactivity under which consumer goods can be exempted from some or all regulatory control requirements because such regulatory requirements are unwarranted.

KEYWORDS: *radiation protection; consumer goods; consumer products; commodities; international regulations; IAEA; WHO; FAO; Codex Alimentarius; Drink Water Guidelines.*

1. INTRODUCTION

The objective of this paper is to present a discussion *document* (hereinafter referred to as the document), which suggests moving towards an internationally harmonized regulatory framework for controlling radioactivity in goods supplied for public consumption or use.

On 18 September 2015, Argentine Nuclear Regulatory Authority (ARN) [Autoridad Regulatoria Nuclear] and the Secretariat of International Atomic Energy Agency (IAEA) agreed on 'Practical Arrangements' setting forth the framework for non-exclusive cooperation between the Parties in the area of radiation safety and monitoring. A relevant activity agreed to be pursued under the 'Practical Arrangements' was the "*development and publication of a harmonized approach for managing radionuclide activity concentrations in food, drinking water and non-food commodities.*"

On 29 January 2019, ARN and the OIEA finalized and published a jointly prepared document under the title '*Radioactivity in Goods Supplied for Public Consumption or Use: Towards an Internationally Harmonized Regulatory Framework* [1], clearly indicating that it was just a discussion document.

2. BACKGROUND

There is an international need for simple and consensual approaches for regulating radioactivity in goods supplied for public consumption and use of universal distribution. The current approaches are complex and contain inconsistencies and incoherencies.

One regulatory difficulty relates to problems of semantics and terminology, which resulted in the absence of encompassing understandings for such goods.. An additional challenge has been the use of dosimetric quantities for the basic paradigm of control. Such dosimetric quantities are not directly measurable and control should be based in radioactivity quantities. These quantities have to be related through models that are unreliable.

Moreover, there are a number of basic questions that have not been fully addressed and need a clear answer. For instance: whether to differentiate between goods that contain radionuclides artificially added and those presenting naturally-occurring and/or artificial radionuclides added due to natural environmental processes; or between goods that are consumed and those that are only used; or between those that are considered edible and those which are not; or between those that are consumed or used preferentially by a given sex or a given age group and those consumed or used indistinctly of sex or age; or between those that have incorporated radionuclides from given initial exposure situation (extant, planned, or emergency situation) and those for which the initial situation is unknown. With reference to the last question it is convenient to recall that radionuclides in consumer goods could already be present in the environment and from there reach the goods (i.e., from an existing or extant situation), or be there due to an authorized discharge from a regulated activity (i.e., from a planned situation), or be the result of a non-anticipated situation (i.e., an emergency situation); in the current international standards, these situations are subject to different regulatory approaches!

3. SEMANTICS AND TERMINOLOGY

A number of terms have been used for regulating consumer goods that have caused some uncertainty. Particularly confusing have been the terms *commodity* and *consumer product* and *consumer good*, and also their main components for public consumption, foodstuff and water. Another confusing term that has been cause of serious harm is the term *contamination*, in particular when it is applied to food or water.

3.1. Commodity and consumer product *vis-à-vis* consumer good

The English term *commodity* has been widely used: in the recommendations of the International Commission on Radiological Protection (ICRP) [2]; in the international standards been established under the aegis of the IAEA [3]; and, even in resolutions of the IAEA General Conference [4]. It has been generally defined as products generally used or consumed by the public that can contain radioactive substances. However in its conventional use, commodity refers to raw material or primary agricultural product that can be bought and sold. Moreover, it is a term that does not accept a direct translation; in fact it has been translated as ‘basic product’. For all these reasons, the use of this term commodity should be discouraged.

In principle, the terms *consumer product* and *consumer good* do not present significant differences; they could be used as quasi-synonyms; in common parlance: both of them refer to all everyday goods supplied for public consumption or use. However the glossary of the current international standards define consumer good as “a device or manufactured item into which radionuclides have **deliberately** been incorporated or produced by activation, or which generates ionizing radiation,

and which can be sold or made available to members of the public without special surveillance or regulatory control after sale” [5]. This definition only encompasses items, such as smoke detectors and luminous dials into which radionuclides have deliberately been incorporated as well as ion generating tubes. It does not include goods such as building materials, ceramic tiles, spa waters, minerals and foodstuffs, and it excludes products and appliances installed in public places [e.g. exit signs]. This glossary definition precludes the use of the term consumer product as a synonym of consumer good for the purpose of the document.

In sum, in order to avoid confusion the document suggest to internationalize the use of the term *consumer goods* for referring to all items supplied for public consumption or use, including merchandise, edible and non-edible products, materials, goods and articles.

3.2. Foodstuff

Food is the quintessential consumer good and a main challenge is to share a common understanding of the concept of food. In modern English, food replaces the archaic term, *aliment*, which is derived from *alere*, meaning to nourish. The Codex Alimentarius, the collection of internationally recognized standards, codes of practice, guidelines, and other recommendations relating to foods, food production, and food safety, is an appropriate reference to understand the meaning of food. For the purpose of the Codex food means any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drink, chewing gum and any substance which has been used in the manufacture, preparation or treatment of “food” but does not include cosmetics or tobacco or substances used only as drugs [5]. Namely, food comprehends any ‘edible’ nutritious substance that people ingest in order to maintain life and growth.

However, this straightforward understanding still presents some basic questions. Since water is a drink, ...Should it be considered food according to the definition?...and, if this is the case.... Why food and water are regulated separately? Drugs are not the sole substance that people ingest. Are other edible substances that people eat for pleasure or vice [nor for nutrition] be also to be considered as food? Moreover, the meaning of ‘edible’ is somehow ambiguous and has cultural connotations; substances that are edible in some cultures are considered inedible in others. For instance, animal internals are a gourmet dish in some countries but are just used for instruments cords in others countries. Moreover, children and adults, women and men, have different food preferences. Some food is consumed primarily by infants and children, while others are consumed only by adults; some are preferred by woman and others by men. How these differences should be accounted for when deciding what concentrations of radionuclides in food may require regulatory control?

The Food and Agriculture Organization of the United Nations, the specialized agency that leads international efforts to defeat hunger and improve nutrition and food security, has a term portal to store, manage and update concepts, terms and definitions [6], but these basic questions are not addressed.

It seems therefore that a basic issue to be addressed for the regulation of consumer good is the precise definition of food.

3.3. Water

It seems that it should not be any thing simpler than the definition of water. However when water is considered a consumer good some issues arise. Water as a consumer good is regulated under the term ‘*drinking*’ water. But the term is not absolutely clear. It has been translated as ‘potable’ water

given the impression that the intention was to refer to what is usually termed ‘tap’ water, i.e., supplied water. But what are termed *packaged waters* are regulated separately than ‘drinking’ water; these are packed waters other than natural mineral waters, which may contain minerals, naturally occurring or intentionally added, and carbon dioxide, naturally occurring or intentionally added, but shall not contain sugars, sweeteners, flavourings or other foodstuffs. Moreover, what are termed *natural mineral waters* are also regulated separately in spite that they are the more common drinking water in many countries [in fact they are unregulated because there are not limit for their radioactivity content; these include: naturally carbonated natural mineral water; non-carbonated natural mineral water; de-carbonated natural mineral water; natural mineral water fortified with carbon dioxide from the source; or carbonated natural mineral water. It seems that this separation into various ‘waters’ does not help the regulation of consumer goods.

3.4. Contamination

But perhaps the more crucial concept for regulating consumer goods is that distinguished with the term *contamination*. It has been formally defined as the *presence* of radioactive substances on surfaces, or within solids, liquids or gases [including the human body], where it is unintended or undesirable, or as the *process* giving rise to such presence [7]. In spite that the formal definition clearly indicate that the term gives no indication of the magnitude of the hazard involved, in practice the term has acquired a connotation that is not intended becoming a quasi-synonym of a dangerous situation.

In relation to consumer goods, contamination involves a particular connotation. Since it conveys the idea of danger, the use of the term ‘contaminated consumer good’ causes public concern, as people perceive it as a binary situation, namely either there is contamination, and some danger, or there is not. Moreover, applied to food it has a religious denotation since its primitive meaning (from Latin *contaminat-, contaminare*) is making a food religiously impure (e.g., ‘non-kosher’).

As a result, the concept of ‘low levels of contamination in a consume goods’ has become incomprehensible for many people, namely or there are contamination and danger or impurity or there are no contamination. These undertones have caused anxiety to people, particularly after accidents [8], and confusion to the authorities when dealing with or discussing radioactivity in consumer goods. The use of the term is particularly unhelpful for consumer goods in which, in general, the content of radioactive substances is low.

4. REGULATORY SITUATION

The regulatory control of consumer goods presenting levels of radioactivity was not historically straightforward and continues to be ambiguous. Some separate international intergovernmental agreements exist, including basic safety standards and specific standards for foodstuff, ‘drinking’ water, other waters, and other goods, but they were and continue to be incoherent and inconsistent.

Historically the regulation of radioactivity in consumer goods was governed by the international Basic Safety Standards (BSS) [9]. The 1962 edition of the BSS established that requirements of notification, registration and licensing could be waived if operations involved the use of radioactive substances at a concentration that did not exceed specified values, except to the intentional addition of radionuclides “in the manufacture of consumer goods such as foodstuffs, pharmaceutical goods, cosmetics and toys”, with the addition that, in order to limit radiation exposure through ingestion and inhalation, maximum permissible concentrations of single radionuclides in air and water were established. [10]. Essentially the same approach was maintained in the 1967 [11] and 1982 editions of the BSS [12].

By the end of the 1980s an international consensus on principles for the scope of regulatory control was being reached [13], and in 1988 a consensus was achieved on the criteria for determining which sources and practices may in a general sense be exempted from regulatory control because they present trivial radiation risks and detriments [14]. Thus, in the 1996 edition of the BSS, exemption values were developed using dose criteria [15]. Using a dosimetric criterion of 10 μSv in a year, conservative and uncertain models were employed to calculate values of activity concentration and of total activity below which compliance with the dose criterion was conjectured to be assured.

In 2000, the IAEA General Conference adopted a resolution requesting the development of radiological criteria for long-lived radionuclides in 'commodities' [4], but an agreement could not be achieved and instead, guidance on application of the concepts of exclusion, exemption and clearance was developed and published in 2004 [16]. In 2007, ICRP issued recommendations aimed at defining the scope of regulatory control [2], which suggested approaches to national authorities for their definition, through regulations, of the extent of radiological protection control measures including those for consumer goods.

Meanwhile, the control of foodstuff become regulated by the Codex Alimentarius Commission established by the The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) [17]. The so-called 'drinking water' become implicitly regulated following WHO's drinking water guidelines [18], [19], although packaged water [20] and mineral water [21] are regulated separately by FAO. Thus, the 2011 Edition of the BSS summarize the status-quo of the situation by assembling all the criteria recommended but without homogenising them into a single approach for the regulatory control of consumer goods [22].

In sum, the relevant documents produced by the IAEA, the Codex Alimentarius Commission, FAO and WHO were considered inconsistent in relation to scope, radiation protection criteria and terminology [23]. Unsurprisingly, in the last years since 2016, the IAEA IAEA General Conference has been mandating the IAEA Secretariat to cooperate with relevant international organizations in developing a harmonized framework for the control of radioactivity in consumer goods.

5. VIEWS FROM STATES

In March 2017, the IAEA and ARN organized in Buenos Aires, Argentina, a Workshop of States' representatives, to discuss the application of current international standards for managing radioactivity in consumer goods. In November 2018, the IAEA organized a similar workshop in Xi'an, China. From these meetings, and other consultations, relevant views from States representatives were extracted.

Their views included the following: international standards ought to be harmonized; good from different exposure situations shall not be differentiated; natural values of radioactivity in the habitat, for food, drinking water and non-edible goods, should be used for reference; the Codex Alimentarius shall include levels for natural radionuclides in food.; the WHO total indicative dose of 0.1 mSv/y cause confusion vis-à-vis the reference level of 1 mSv/y in international safety standards [countries cannot comply with this value as they have higher values in their natural environment]; same criteria should apply to 'drinking' water, packed water and natural mineral water; bands of values for the regulation of activity in consumer goods shall not be used, since people and authorities usually believe that the minimum values are the safe ones.; it should be an international agreement on the status of any numbers that be finally established, namely: i.e. are they advisory, limits, upper bounds, lower bounds, action levels, trigger levels etc.; situations should be avoided where goods that are not regulated cannot be freely transported, and *vice versa*,

and, the regulatory control of consumer goods should be based on activity values due to the fact that making dose estimates can have a great deal of uncertainty due to parameters' variability.

6. CONCLUDING RECOMMENDATIONS

The document concludes with a Decalogue of recommendations as follows:

- 6.1. **Terms being used, such as 'commodities' and 'consumer products' should be replaced by the term consumer goods defined as follows: *Consumer goods are those products supplied for public consumption or use, including merchandise, edible and non-edible commodities, and other materials, goods or articles.*** This new definition does not include items to which radioactive substances are intentionally added, for which the existing term radioactive consumer products should be used.
- 6.2. **The use of the term contamination should be avoided when referring to consumer goods.** Rather than referring to contaminated consumer goods, reference should be made to *the presence of radionuclides in consumer goods.*
- 6.3. **The quantity to be used for regulating consumer goods is the [radio]activity, and its derivatives, e.g., activity per unit volume or per unit weight or per unit surface area of the relevant good.** It is unreasonable, for practical and epistemological reasons, to use dosimetric quantities as the primary basis for controlling the presence of radioactivity in consumer goods. These quantities are generally not measurable in relation to the consumption or use of consumer goods and their estimation requires subjective modelling, often with substantial uncertainties.
- 6.4. **The presence of radionuclides in consumer goods should be regulated, regardless of the origin of the radionuclides, because radiation risks are independent of the origin of the activity.** I.e., specifically, consumer goods containing naturally occurring radionuclides and those containing artificial radionuclides should be regulated using the same criteria and regulations. Notwithstanding the above, regulations may also take account of the amenability of control, and possibly also the social expectations of those affected.
- 6.5. **The amount of natural radionuclides present in widely available consumer goods could serve as a good indicator of acceptable levels of radioactivity of any origin in consumer goods.** It is important to establish the variability that exists in the concentrations of various radionuclides in consumer goods [including food and water currently freely available on the market.
- 6.6. **National frameworks should be coherent and consistent with consensual international guidance established by the governing bodies of relevant international intergovernmental organizations.** This is essential due to the ubiquity and general global distribution of consumer goods.
- 6.7. **The regulation of consumer goods should neither be based on the exposure situation from which they are derived (e.g., planned, emergency or existing) nor on the type of exposure being incurred (e.g., occupational or public); namely, *all those affected by consumer goods should be considered members of the public undergoing an exposure situation without qualification.*** The reason is that it is not always possible to identify exactly either the radiation exposure situation that has generated the presence of radioactivity in consumer goods. For the consumer it is irrelevant which type of exposure situation has given rise to the presence of radioactivity in consumer goods.
- 6.8. **The control criteria for consumer goods should take into account conflicting views on edibility.** The separation of consumer goods between those that are edible and those that are considered inedible is not universal because the definition of edibility involves cultural attitudes. However, since consumer goods generally recognized as edible might

be of particular concern to people; in such cases, an *ad hoc* approach for dealing separately with edible and non-edible consumer goods need to be considered.

- 6.9. Activity levels in consumer goods that are considered safe for women and children should be used as the main criteria, which should be established based on consideration of a notional ‘person’ representative of those at higher risk.** Criteria for controlling consumer goods that introduce differences among gender or age are difficult to implement in practice; and women and children are generally more sensitive to radiation than adult men
- 6.10. National systems for controlling consumer goods could be framed on the following criteria: [i] States should establish the levels of radioactivity under which consumer goods can be *excluded* from regulatory control, because such control is unamenable** (For example, the doses received from 40K in the diet is normally excluded from regulatory control because of the fact that it is homeostatically controlled in the body), **and [ii] Regulators should establish the levels of radioactivity under which consumer goods can be *exempted* from some or all regulatory control requirements because such regulatory requirements are unwarranted.**

7. EPILOGUE

It is expected that the suggestions in the document will be helpful for clarifying a number of issues related to the control of radioactivity in consumer goods. Until now, these issues have not been properly resolved and have been the subject of differing interpretations and confusion. It seems to be crucial that the relevant intergovernmental international bodies to address and resolve the many issues referred to in the document.

8. ACKNOWLEDGMENTS

Acknowledgments are given to:

- Miroslav Pinak, Head of the IAEA Radiation Safety & Monitoring Section, who was the initiator of the ‘Practical Arrangements’ initiative
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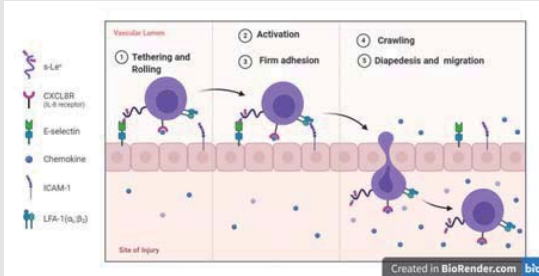
Adhesion Molecules Expression: Beta 1 Integrin and ICAM-1 as Potential Markers of Cutaneous Radiation Injuries Induced by Ionizing Radiation Overexposures

Lendoiro, N.; de la Vega, A.; Portas, M.; Dubner, D. and Rossini, A.

INTRODUCTION

During the **inflammatory response**, there is a process of leukocyte extravasation that involves the **migration** of these cells from the bloodstream towards **target tissues**.

Cell adhesion molecules (CAMs) mediate interactions between blood cells and endothelial cells as a response to inflammation under certain conditions such as overexposure to ionizing radiation. On the other hand, the **beta integrin** family of proteins interacts with the associated ligand (intercellular adhesion molecules) in the vascular endothelium. This transient **binding** results in further leukocyte **activation** and subsequent **firm adhesion** and **transendothelial migration** into sites of inflammation.



OBJECTIVE

The present study examines the expression of two adhesion molecules: Beta 1 integrin and ICAM-1, using flow cytometry and immunohistochemical techniques, in blood samples and biopsies from patients overexposed to ionizing radiation and the possible role of this interaction between these molecules in the initial phases of infiltration into the tissue affected by radiation exposure as a useful tool for its application in an emergency.

MATERIALS AND METHODS

- Patients: Patients referred to the Radiopathology Committee of Hospital de Quemados del Gobierno de la Ciudad de Buenos Aires (Burn Hospital) for the diagnosis and therapy of Cutaneous Radiation Syndrome. The follow up of 3 patients showing cutaneous reactions score 4 according to the RTOG / EORTC is reported in this study.
- Flow cytometry: The assessment of B1 integrin (CD29) was performed by staining 50 µl of whole blood with Ab anti CD29 labelled FITC.
- Histological analysis: Histological examination of 0.3 cm tissue sections of skin was performed after fixation and staining with hematoxylin-eosin (H&E).
- Immunohistochemical techniques: Tissue sections from biopsies were stained using a FITC-conjugated monoclonal antibody mouse anti-human ICAM-1 (CD54).

RESULTS

PATIENT 1

69-year-old male patient treated with radiotherapy at his 36 years due to a right leg angioma. According to the equipment and protocol applied at the time of treatment, it can be inferred that the dose delivered to the leg angioma was around 50–60 Gy (2.0 Gy/day given 5 days/week). Initially, ulcers appeared approximately every 10 years. Over time, the latency period shortened. In addition, the severity and frequency of the ulcers increased. Blood sample and biopsy were obtained during a crisis, observing a high $\beta 1$ integrin value.

Sample	Patient MFI value for $\beta 1$ integrin	Normal value for $\beta 1$ integrin
Patient 1	18.7	8.75 ± 3.77

Patient 1 biopsy

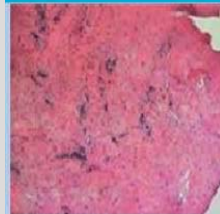


Figure 1: H&E-Cutaneous tissue with ulceration of the surface. Vessels with collapse of their lumen due to fibrosis compression of the surrounding tissues and perivascular lymphocytic infiltrates.

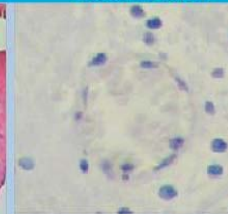


Figure 2: Immunohistochemical technic- Control ICAM-1 negative mark.



Figure 3: Positive mark for ICAM-1 on endothelial cells of vessel walls.

PATIENT 2

66-year-old male patient with paroxysmal refractory atrial flutter, had a fluoroscopy procedure 23 years ago and presented an ulcer on his back. The lesion was treated as a conventional burn, the skin was removed and the patient received an autologous graft that did not succeed. As a consequence of this treatment the ulcer intensified. In this crisis, it was obtained a high $\beta 1$ Integrin value evaluated by flow cytometry.

Sample	MFI value for $\beta 1$ integrin	Normal value for $\beta 1$ integrin
Patient 2	19.5	8.75 ± 3.77

Patient 2 biopsy

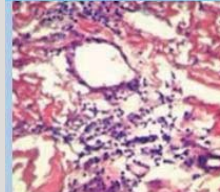


Figure 4: H&E-Cutaneous tissue with perivascular lymphocytic infiltrates.

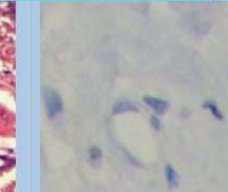


Figure 5: Immunohistochemical technic- Control ICAM-1 negative mark.

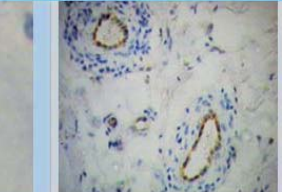


Figure 6: Positive mark for ICAM-1 on endothelial cells of vessel walls with perivascular lymphocytic infiltrates.

PATIENT 3

61-year-old male patient who had undergone a fluoroscopy procedure, developing a necrotic ulcer grade 4 RTOG/EORTC four months after exposure in the dorsal area in 2003. The follow up was performed until 2010, the patient discontinued the treatment and returned in 2018 showing a radiation induced malignancy with bleeding and severe pain. $\beta 1$ Integrin value for the year 2018 was considerable which correlates with the clinical symptoms (inflammatory response).

Sample	MFI value for $\beta 1$ integrin	Normal value for $\beta 1$ integrin
Patient 3	18.3	8.75 ± 3.77

Patient 3 biopsy

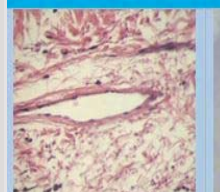


Figure 7: H&E-Cutaneous tissue with perivascular lymphocytic infiltrates.

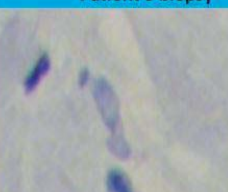


Figure 8: Immunohistochemical technic- Control ICAM-1 negative mark.

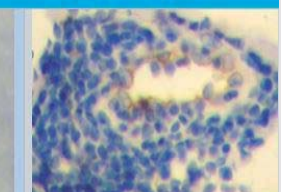


Figure 9: Positive mark for ICAM-1 on endothelial cells of vessel walls with perivascular lymphocytic infiltrates.

CONCLUSIONS

This study contributes to understanding the role of these adhesion molecules on irradiated tissue. The analysis of these markers is useful to physicians to predict inflammatory waves and improve the treatment. $\beta 1$ integrin values in patients were significantly greater than control values. In addition, ICAM-1 on endothelial cells from the vessels of these patients was positive. The same ICAM-1 staining was not observed in healthy tissue. This shows an association between high levels of $\beta 1$ integrin on blood cells and the expression of ICAM-1 on endothelial cells of grade 4 RTOG / EORTC patients. Flow cytometry techniques are of great importance during an emergency due to the high speed of the results. They can be used together with other techniques to guide personalized treatments of victims. This work adds new evidence that supports the use of $\beta 1$ integrin, in combination with other inflammatory indicators, as a follow-up marker of chronic radio-induced inflammation process just as its response to therapeutic treatments.

Being There and Not Being There. Pandemic's Challenges on Teaching-Learning Process

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BEING THERE AND NOT BEING THERE. PANDEMIC'S CHALLENGES ON TEACHING-LEARNING PROCESS

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ABSTRACT

Beyond the health effects over individuals, the COVID-19 pandemic generated important alterations in the way that we interact. But even more, these disruptions have also raised the need to reflect about the ideas that we have over the ways of our ties.

The educational phenomenon is, among other things, also a way in which individuals bond. There are typical ways of ties between the different actors in this social fact. These relationships take place, undoubtedly, in specific spaces (e.g. classrooms, laboratories) and are mediated by a pool of varied technologies (blackboards, screens, slides, detectors, programs, assay tubes, microscopes, an infinity of elements that participate in teaching-learning process).

Now, what happen when the pandemic imposes restrictions for people mobility, affecting the possibility of that particular meeting between professors, students, classrooms and learning tools? There is no way to bypass that question.

The abandonment – intermittent or protracted – of the classroom, modify the way of the characteristic bonds between all the educational activities' players. Thus is necessary to reflect about what “be there” means. But also, if the educational activities do not want to be interrupted, its reverse form, “not be there”, should be taken into account. More specifically, this “separation” of bodies, spaces and tools made clear that there would be an impact on the educational process: in the communication modalities, in the knowledge transfer, in the ways of evaluation, in the practice activities. There was no aspect that was not modify by this distancing.

In this article we pose a set of questions to be debated about the, by the way, not so novel situation of the “virtualized education”. As the authors are part of a group dedicated specifically to the management of education in radiation protection, this work is based on the experience acquired in this field over the last 5 years and, particularly, about the challenges that the pandemic has imposed us for the development of careers and courses.

1. Introduction

Beyond the health effects over individuals, the COVID-19 pandemic generated important alterations in the way that we interact. But even more, these disruptions have also raised the need to reflect about the ideas that we have over the ways of our ties.

The educational phenomenon is, among other things, also a way in which individuals bond. There are typical ways of ties between the different actors in this social fact. These relationships take place, undoubtedly, in specific spaces (e.g. classrooms, laboratories) and are mediated by a pool of varied technologies (blackboards, screens, slides, detectors, programs, assay tubes, microscopes, an infinity of elements that participate in teaching-learning process).

Now, what happens when the pandemic imposes restrictions on people's mobility, affecting the possibility of that particular meeting between professors, students, classrooms and learning tools? There is no way to bypass that question.

The abandonment – intermittent or protracted – of the classroom, modifies the way of the characteristic bonds between all the educational activities' players. Thus it is necessary to reflect

about what “be there” means. But also, if the educational activities do not want to be interrupted, its reverse form, “not be there”, should be taken into account. More specifically, this “separation” of bodies, spaces and tools made clear that there would be an impact on the educational process: the communication modalities, the knowledge transfer, the ways of evaluation, the practice activities. There was no aspect that was not modified by this distancing.

In this paper, we propose to raise some reflections - some as questions - based on the experience we have gained as part of a team that develops a variety of educational activities in the Radiation Protection field. In particular, about the situation that we have had faced since March 2020 as consequence of the effects of the coronavirus pandemic. We will focus especially on the responses to a series of practical and theoretical dilemmas that we had to sort out in order to continue the *Specialization in Radiation Protection and the Safety of Radiation Sources* and the *Basic Course in Radiation Protection*.

2. The “new” not “so new”

This terrible illness that left millions of deaths all around the world and that hit much harder to the most vulnerable social sectors due to its effects -not only on health but also economics, psychological and social ties-, could not fail to also affect all levels of the educational system. The deep impact that it has caused in all the levels of life marked in our opinion the attitude, desperate and urgent in some cases, to give answers. Uncomfortable, rushed, often unreflective, contradictory replies to provide a possible exit to the crisis. A crisis that in an evident manner clearly exposed some weaknesses and problems that societies and their institutions already had before the pandemic.

We must therefore recognize that, although this global and multifaceted crisis has suddenly and abruptly placed us in an undesirable situation, some of the problems that were posed to the educational system in general were not new. It just updated them. In fact, it could be said that the pandemic adds a further degree of critical complexity to a higher education that, practically all around the world but particularly in our region, was already facing unresolved challenges¹. It will be necessary to evaluate to what extent the answers that have been given were correct, if they were suitable to this particular context, if they pose a transformation for the near future. We have time to do that evaluation, but it is necessary.

Therefore, allow us to start this article pointing out some elements arranged here for a joint reflection about these problems – new and not so new – that the pandemic updated. From here, we will do a brief description of the characteristics of our educational activities to then show what answers we have given to the problems that we had to face. We hope that in a short time we could present another paper with a solid evaluation of our activity during the pandemic.

As it is clear, the first problem posed by the pandemic and its restrictions is the possibility of continuing educational activities. At least, as they were developing. The UNESCO-IESALC estimations, show that the temporary closure affects approximately 23.4 million of higher education students and 1.4 million of professors in Latin America and the Caribbean².

In particular, because physical reunion was no longer possible in the classroom space. With the exception of those programs developed and carried out under “distance learning” methodologies- due to their particular way of organizing resources and interactions between students and professors- the development of face-to-face programs was confronted with the following dilemma: “stopping and transforming”, or only “stop” for undetermined time.

Let's set aside the multiple differences between the policies that countries took to face this health crisis in relation to mobility restrictions, access to public spaces, and specific policies for educational activities. As was shown in a variety of official reports, “stop” for an uncertain period was not the privileged option for most of the educational institutions in the world³. At the same time, public organizations and private companies arranged a home-office modality for the continuity of the work. Universities and other educational entities started to organize their administrative functions in the same way, for instance, remote attention of the students. In this way, the decision to transform in order to move forward was followed by an immediate series of questions: What to transform?, how to do it?,

¹ Instituto Internacional para la Educación Superior en América Latina y el Caribe (IESALC-UNESCO), Covid-19 y Educación Superior: de los efectos inmediatos al día después, 6 de abril de 2020, pág. 11

² IESALC, op. cit pág. 9.

³ Ídem IESALC, pág. 11.

how to change and at the same time not substantively modify the purposes of the programs and the educational quality?

Obviously the long experience of the so-called distance education meant a perspective and a tangible possibility. Looking into its characteristics and shapes, its scopes and potentialities, its necessary resources, but also its weaknesses and problems became a primary task.

Based on this possibility, two interconnected issues are placed in the center of the specific education reflection: the physical split of the main actors (teachers and students) and the use of applied technology to education.

Pandemic has demonstrated the need and the urgency to think about transforming the classroom into new and creative spaces that could cause productive experiences during the teaching and learning process. Because of that the use of technologies and active methodologies become the key characters.

However, these changes were already happening in educational contexts before the pandemic. The Organization of Ibero-American States (OEI) reported the growth in the participation of students in the distance modality in higher education since the year 2000. In a seven years period (2010-2017) the enrollment of "distance" university students raised 72.9% in the region, while the "face to face" modality grew 27.3% in the same period. In this sense, the proportion of "distance students" varied from 11.7% to 15.3% in the whole region and in the mentioned period, which adds up to a total of 4.3 million people⁴. It is true that the penetration of this modality is still budding and heterogeneous among the countries of the region. This disparity is based on the economic and social inequalities that impact on the access and permanency in higher education, as well as the so-called "digital divide", that is, the unequal access to information and communication technologies (ICTs). Anyway, the growth is constant and it has not waited for the pandemic to make it a trend.

Specialized literature on the subject has been expressing it systematically: it is necessary to reflect about the education outside the classroom, the education mediated by specialized technologies and adequate methodologies. Predictable as it is, these formats redefine the educational space. For the most optimistic people, they are better suited for a daily reality characterized by the massive use of social networks, communication technologies, and the internet. A reality that has substantially modified the ties between individuals. In other words, according to this analysis, it would have produced a "distance phenomenon" between the new forms of socialization among young people and what is traditionally offered by the educational system.

González-Sanmamed expresses it as,

Tanto desde el punto de vista cuantitativo como cualitativo, los estudiantes que llegan a las instituciones de educación superior son totalmente diferentes a los que estaban en las aulas universitarias hace solo unas décadas (...) la universidad se enfrenta a un problema de masificación que hace difícil mantener los deseados niveles de calidad y de atención personalizada que se requieren. Los jóvenes, que han nacido y crecido en un entorno muy distinto al de generaciones anteriores, reflejan formatos culturales totalmente diferentes en sus comportamientos, relaciones y expectativas, lo que sin duda revierte de manera directa en su manera de estar, participar y aprender en la universidad⁵

The expansion of the use of ICTs, caused an enormous circulation of information. This information can also be created and shared autonomously and openly, generating a strong capacity for manoeuvre. Some authors consider the idea of "students-prosumers"⁶ to characterize the students as protagonists of the teaching and learning process.

⁴ Observatorio Iberoamericano para la Ciencia, la Tecnología y la Sociedad (OCTS-OEI), Informe de Coyuntura nº6, diciembre de 2019. <http://octs.ricyt.org/coyuntura/coyuntura06.html>

⁵ González-Sanmamed, M., Sangrà, A., Souto-Seijo, A., y Estévez Blanco, I. (2018). "Ecologías de aprendizaje en la Era digital: desafíos para la educación superior". *Publicaciones*, 48(1), 25–45 doi:10.30827/publicaciones.v48i1.7329

⁶ The original concept was coined by Alvin Toffler in his book *The Third Wave* combining the terms "producer and consumer." Although there the "prosumer" was defined as a consumer who participates in the production process of the goods and / or services bought by himself, some authors argue that this idea should be extended to the characterization of current university students. Cfr. Rodríguez, E., Moreira N. y Hortegano, R. (2021).

In summary, as stated above, the urgency to respond to the problems posed by the pandemic suddenly renewed a deep debate about the current modalities in all levels of education, in particular the higher level.

3- Technology and separation

During the pandemic, most university educational institutions have chosen to continue offering ordinary courses through virtual platforms, maintaining (in spite of the changes in the modality) the official certification and guaranteeing the same credits system. In this way, they tried to follow the fundamental principle of national policies in education: to do everything possible to assure the continuity of the teaching activity.

As is predictable, replicating face-to-face lectures through ICTs that allow remote contact poses new problems. The first and most obvious is analysed by Kohls-Santos,

*(...) solo hacer uso de las TDIC y estar físicamente distante no configura la Educación a Distancia (EaD), lo que se está realizando es una Atención Remota de Emergencia (ARE) que no tiene la misma planificación y organización que la EaD. Pues, la EaD implica una planificación previa, considerar el perfil del alumno y docente, además desarrollar estrategias de enseñanza y aprendizaje a mediano y largo plazo*⁷

Through the “strategies of continuity”, the universities made an enormous effort of “no stopping”. However, the immediate translation of the usual forms of education to a format based on virtual platforms does not magically convert it into what is known as distance learning, since it implies its own characteristics that are not exhausted in the use of technologies and in the distance of the bodies. It is necessary, at least, to have contents planned and designed specifically for that purpose. Given the suddenness of the crisis, an attempt was made to alleviate the absence of face to face classes with remote classes, an emergency model under the pressure of the situation.

The necessity of “transforming” is still latent. And technological progress tempts us to turn towards formats that do not oblige a constant face to face modality in the classrooms. In this sense, resizing the use of technologies in the educational context involves an analysis of “pros and cons” because both factors (non presence & technology) are closely linked. Although this situation does not necessarily imply a complete turnaround to Distance Education modalities, the vast experience in that format, its lessons learned, the debates developed in this field deserve serious consideration.

Therefore, we point out two axes to debate collectively:

- a. Use of technological media in the educational experience. (transforming space and time).
- b. The distance of the bodies.

A – For what reasons are we concerned about “technologizing” the educational experience?

At this point, a minimal sociological consideration seems relevant to us: we start from the belief that face to face education is the “normal” and any deviation appears to us as an aberration. It is not only the idea of a “resistance to change”, but rather, a similar but not identical idea: associating “normal” to “good”. A noun does not intrinsically deserve a specific adjective. It means, to associate a situation with a value judgement, an evaluation is necessary. However, often when we face a deviation from normality, the excuse of the “good” comes in order to try to avoid it.

It is conceivable that in the educational context an immediate attitude has emerged: a negative reaction. A reaction that could be translated as follows: **leaving the face to face modality will affect the quality of education**. While in general we are amazed by technological novelties, we nevertheless put *en garde* when it comes to education. Of course, if normality is not intrinsically “good”, neither is the “change” itself. The paradox is that “the technological” is often also related with a positive appreciation: technology modernizes, solves problems, “technology is good”. This concern is not only on the professors’ side or in educational institutions. During the pandemic, concern was also manifested by students’ sectors. In the context of the British higher education, for example, more than 260,000 students signed a petition for a part of their tuition to be returned, under the assumption that

“Enseñanza virtual en tiempos de emergencias: continuidades y transformaciones”. *Revista Iberoamericana de Educación*, 86(2), 141-186

⁷ Kohls-Santos, P. (2021). “Covid-19 y educación: experiencias y perspectivas docentes en la educación superior”. *Revista Iberoamericana de Educación*, 86(2), 31-44. <https://doi.org/10.35362/rie8624344>

online teaching does not have the same value⁸. In Argentina, particularly in the elementary level, parents defied sanitary restrictions during the highest peak of COVID-19 cases by asking that their children return to classrooms⁹.

As long as we do not pose a critical reflection about our –good- educational normality and its meeting with –good- technology, we will not be able to seriously consider its consequences. We should, therefore, strongly consider critical and reflexive attitudes about the future of education.

Because of length reasons, this is not the place to extend a depth study about the future. However, we consider it appropriate to set out which are the “threats” to normality that poses the use of new technologies in the educational context.

We could think that technologies applied to a particular field brings an improvement in some practical and concrete issues. It is true that it is also necessary to evaluate if these technologies actually resolve those problems, to what extent they do that, if they pose new problematic situations, to evaluate its pros and cons.

What are the potential transformations that these technologies present to us? Here, we listed some summarized features that have been relieved from specialized literature.

- Student autonomy: the use of educational technologies **makes the time more flexible** to the reality of the students, allowing them to decide in what moment and place they prefer to work on their study. This encourages them to work outside the class time and thus it results in an **active learning**. Some authors, emphasizes the idea that this constitute a sort of **empowerment** of the student since their decisions assume a central role in the learning process¹⁰.
- A new dynamic in teaching methods: the introduction of audiovisual formats makes it possible to increase new languages based on the **mixture of oral language, images and sound**. That is, the communicative ways between teachers and students are expanded. This poses the possibility of using more adequate formats for each topic, practice or activity. And also a visual stimulation¹¹.
- Accessibility to educational platforms: educational platforms, (e.g. MOODLE) make it possible to centralize information from students’ and teachers’ profiles, activities, exams, bibliographic and audiovisual material for classes, marks, just to mention some of the possibilities that these technologies grant. It also implies **full accessibility** to the information available anytime for all participants. Using the materials as decided, or systematically repeating the visualization of the classes is a novel contribution. This technological solution facilitates the autonomy of the student. The more students engage with their work it encourages discussions during classes. An added value: it also minimizes the use of paper.
- Communication between actors: technologies make it possible to be “**connected**” permanently. It allows a degree of interaction between equals that has never been experienced before. In relation to the interaction between teachers and students, communication can be more effective, fast and adequate, through forums or private messages.

⁸ Certainly this situation occurred in a pandemic context in which the proposed teaching methods, as noted, constitute an emergency exit and not a long-term plan. Therefore, it is not clear whether there would be such opposition to distance educational planning. In the same way, it is not clear if students consider that online education would have a lower monetary cost, or if the monetary cost should be lower because educational quality was affected. In any case, there is a question to be analyzed.

<https://poetsandquants.com/2020/03/29/pq-survey-a-third-of-admits-may-defer-while-43-wanttuition-lowered-if-classes-are-online/>

⁹ Cfr. <https://www.perfil.com/noticias/politica/clases-presenciales-en-caba-protestas-y-reclamos-judiciales-de-padres-autoconvocados.phtml>; <https://www.eldia.com/nota/2021-5-13-11-47-0-padres-convocan-a-una-vigilia-en-la-gobernacion-por-vuelta-de-las-clases-presenciales-la-ciudad>

¹⁰ González-Sanmamed, op cit.

¹¹ Aljawarneh, Shadi, “Reviewing and exploring innovative ubiquitous learning tools in higher education”, in *Journal of Computing in Higher Education*, Springer, 2019, <https://doi.org/10.1007/s12528-019-09207-0>

B- The question of the non-physical presence of students in classrooms.

Classroom seems to have a particular aura. A sacred space in which believers converge to receive “the word”. And in a certain manner it is. As Ximenes Martins describes,

A Concepção Pedagógica Tradicional pressupõe centralidade no professor e nos conteúdos disciplinares, que são transmitidos aos alunos, tendo como principal foco a memorização desses conteúdos¹²

The comparison can be excessive. Maybe... let’s take it at least with a heuristic criterion to reflect on it. The truth is that it is a model deeply rooted in our idiosyncrasy and tradition about how education should be.

New educational formats based on the use of technologies poses the end of the classroom as the unique space, to consider it as one more among others in the teaching-learning process. “Being there” would no longer constitute the organizing principle of the educational fact. Or better, “not being there” to be in another way, in another space, in the so-called “virtual space”.

It seems evident that this changing in space supposes different interaction modes, different abilities, different sensations. But here it is important to reflect about how the distance of the bodies impact. And, of course, to assess its benefits; if there are any...

Revising specialized literature, we found arguments that intend to show if this distance constitutes a commitment with the educational process and its quality. In general terms, the distance does not appear as a positive value in itself, but is inevitably associated with the use of technologies applied to education. Finally, what is discussed is whether the impact is negative or if there is not such impact.

We will refer to “problems” related exclusively to the “separation of bodies” that are expressed in professional manuscripts dedicated to this topic:

- The autonomy of the student presents an opposite side: the need for more discipline and compromise on their part.
- Validation through learning exams is problematized.
- Communication between students and teachers is altered.
- Difficulty or impossibility of carrying out some practices (laboratory work, technical visits, among others).
- Interactions between students are affected.
- The importance of monitoring student performance is reinforced, that could be of irregular compliance in different institutions and/or professors.
- Difficulty in the perception of non-verbal elements that permit identifying the comprehension of certain topics by the student.

As it was pointed out before, this list of problems represents a summarized detail of issues that are put into debate due to the distance assumed between the actors in the teaching-learning process. Likewise, what is discussed is to what extent it has an impact on educational quality, or whether the educational technologies make it possible to avoid the supposed negative impact. Of course, the balances are varied and emphasise on different points, such as whether it is an elementary or higher level students, if it is a pre-established distance education program, or if the “contract” changed modifying the face to face modality, among other factors.

However, the idea of distance can be perceived in a different way, not only focusing on the physical separation of bodies.

In the 1970s Michael G. Moore presented pioneering work on the consequences of distance education. In this work, the author conceptualizes the idea of “transactional distance” to refer to the communicative and psychological gap that is established between teaching behaviours – and those of the “teachers” – and the learning behaviours – and of the students.

With separation there is a psychological and communications space to be crossed, a space of potential misunderstanding between the inputs of the instructor and those of the learner. It is this psychological and communications space that is the transactional distance¹³

¹² Ximenes Martins, Ronei, A Covid-19 e o fim da educação a distância: um ensaio. *Em Rede –Revista de educação a distância*, 2020, v. 7, n. 1

Although Moore develops these ideas in a context in which a very particular form of distance education – correspondence education – still was alive, and not the current forms, the focus of his attention is not placed on the physical separation of students with respect to their peers, teachers and educational spaces. Attention is focused on the assessment of three concrete variables:

The extent of transactional distance in an educational programme is a function of these three sets of variables. These are not technological or communications variables, but variables in teaching and in learning and in the interaction of teaching and learning. These clusters of variables are named Dialogue (the interaction between learners and teachers), Structure (the structure of instructional programmes) and Learner Autonomy (the nature and degree of self-directedness of the learner)¹⁴

Of course, there is no need to agree with Moore's theoretical proposal. However, this idea of "distance" as a situation that can still be seen in face to face forms, allows us to focus on practical problems that run through the entire educational process and that the use of technologies in this field updates.

4- Hybrid forms

a. Synchronous and asynchronous interaction

So far we tried to capture some general considerations about the scope and problems of the use of the technologies applied to education and its associated "separation of bodies". But we have not addressed the possibility of establishing hybrid (combining face to face-distance learning) mechanisms.

Such is the case of the synchronous and asynchronous modalities of lectures and activities. Some specialists prefer to talk about the synchronous and asynchronous **interaction** or **communication**, since what is at stake is the interaction between educative process actors¹⁵.

Defined as a sort of communication based on the use of e-mail – or similar forms – and with the teacher playing the role of facilitator in front of students, the asynchronous communication has the merit to promote an anytime-anywhere e-learning. In this modality can be included all kinds of audiovisual materials that allow the students to study at their own rhythm. It can be considered as the form that historically has adopted the distance learning modality. However, it is no longer the only way to relate students in on-line lectures.

Synchronous interactions have won a lot of space – particularly during pandemic – and it is converting into an integral part of the communication between educational process actors. Due to its characteristics, broadcasted live classes that allow an immediate feedback between students and between teachers and students, participants can feel more commitment with the on-line experience.

Lynette Watts work¹⁶, that revises the specialized literature about the comparison of these two modalities, shows some relevant aspects:

- Several researchers argued asynchronous interactions should be used for group work, especially when content is difficult and requires reflection before posting
- using synchronous interactions (is better) for group projects, because they found the media richness of synchronous tools assisted in the deeper learning process
- Other researchers posited synchronous interactions should be used for socializing, planning of activities, and discussing less complex tasks

As conclusions, we highlight:

- instructors must examine course content, learner motivation and needs, and learning outcomes before deciding on the types of interaction to be woven into course work

¹³ Moore, M. "Theory of transactional distance" in Keegan, D., ed., *Theoretical Principles of Distance Education* (1997), Routledge, pp. 22-38.

¹⁴ Moore, op. cit. pag. 22

¹⁵ Cfr. Hratinski, S.; "Asynchronous and synchronous e-learning" in *Educause Quarterly*, 2008, n4.

¹⁶ Cfr. Watts, L. "Synchronous and asynchronous communication in distance learning: a review of the literature", *Quarterly Review of Distance Education*, v17 n1 p23-32 2016

- just as important as instructor-student support is university support to address issues arising with the technology because of the frustration technical issues can cause
- not to make the assumption all students are proficient, or even familiar, with online learning platforms
- instructors should provide technical support to teach students to use the technology for interacting in their courses. If students become frustrated in trying to use the technology, they may not learn the content¹⁷

Independently of the methods, it is emphasised that the motivation of the student is a key element for the success of the educational strategy. In this way, it is postulated that when the student is compromised with the study, the levels of satisfaction with distance learning and the learning results are raised. Therefore, a key factor is that all strategies consider this topic at the moment of designing the educational activities.

b. Blended learning

At the international level, a modality that has won space in the universities is the so-called blended learning¹⁸. The proposal of this model is the combination of the elements that characterize a face to face class with an education mediated by the use of technology. Clearly, it is a format that constitutes a way out of the division between face to face and distance education.

Just as it is important to consider the adaptation of the educational formats to the new social realities, it will be also relevant to understand that the use of technology cannot be thought of as an end itself. This idea of combining modalities generates a frame that increases the possibility of imagining strategies that do not trust in just one technology, nor in just one methodology. Its purpose is to guarantee a better reach to more students or to avoid that the technological solutions do not damage those who are in a disadvantageous situation because of the technological gap. The general approach to this modality is to find the most appropriate combination of methodologies and resources to improve the pedagogic impact. In other words, combining the best of the face to face modality with the potential of the technologies as the foundation of the renewal and the improvement of the educational quality.

5- Transforming?

The experience that we have won during the pandemic and the evaluation of the debates about educational modalities allow us to deploy some considerations that could turn into pillars of the discussion about the potential paths for future strategies.

In this way, we think it is convenient to finalize this section proposing a set of problematic issues – that are no more than questions – that arise when we consider the possibility of “stopping and transforming”.

- a. At the moment of imagining educational technologies, what are the most adequate digital resources for helping students to succeed during the teaching-learning process? Related to that, we should consider not to start from abstract principles, as for example supposing that the students – or the applicants – have a similar level of access to the technology. The digital divide exists. The disparity is not the result of a pandemic, it is an actual reality that institutions have to face, and that indicates not only big differences in the access to technological resources, or in the quality of the connectivity. But also in the different prior skills of the citizens in the use of software. This could let outside the most vulnerable sectors of society or, that they receive a less quality education due to having not considered the strategies in a clever manner.
- b. Do we learn better from people or from software and applications? Studies reveal similar results from both. However, there is a selection of variables that should be consider to get an answer to this question: the educational level of the activity, the previous experience of the students, the connectivity, the sort of the language used, the capability for motivating students, the quality of the design of the activities, the skills and competences are necessities in students and teachers, just to mention some relevant factors.
- c. How to organize contents in order to boost them in a new virtualized environment? Understanding the different languages that make possible new technologies, the ways in which they are received

¹⁷ Cfr. Watts, op. cit. p. 30

¹⁸ It can also be read as "bimodal", "combined", "hybrid teaching", to cite a few examples.

- by students, it supposes leaving the univocal logic of “the word” to dive into the culture of the image. It is probable that students have already been immersed into these cultural forms, but it is also probable that teachers who design educational programs should process this cultural change. It is not only a question of knowing how to handle software, but also that the image communicates in another way.
- d. How to strengthen students’ autonomy, without leaving them to their fate? Although we recognize the importance of strengthening the autonomy of the student, which also means strengthening the independence of judgement and their critical thinking, it does not mean that the teaching and institutional activity should not be compromised with the learning process of the student. The monitoring of students’ formative progress is still a responsibility of the teaching side.
 - e. How to incorporate the ICTs to the teaching learning process? Are all the contents and activities capable of “leaving the classroom” and navigating correctly in the virtual environment? We understand that there are no natural laws that determine a unique sort of strategy. Professors and managers should evaluate each case.
 - f. There are two elements that do not appear clearly in the literature, but should be visualised: reader capacity and the concentration of the students. Designing syllabi is also considering the study material. With this criteria, we will have to evaluate not only the best materials by its quality and its communicative capability, but also how clever we are to accompany these materials to strengthen the reading and comprehension skills and the attention of the student.
 - g. Are teachers the only ones who have the responsibility to deal with the students? It is true that teachers have greater contact with students. But institutions are an inescapable part of the educational process. The new virtual environment promises new forms of institutional participation and support.
 - h. Physical distance does not suppose social distance. As stated before, it is possible to inhabit the same classroom but “to be kilometres away” (communicative distance). On the other hand, the effective physical distance, commits to reflect on the way to strengthen the commitment and the attention of the students.
 - i. And finally, how to implement modifications without altering the quality of the educational process? Even better, in what way can the technological leap mean a quality leap in the teaching and learning process?

6- PGEC in Argentina

In 1979, Argentina began its long and recognized trajectory in radiation & nuclear safety education. Since then, he has continuously developed a course (without a bachelor's degree) designed especially for technicians from regulatory bodies, staff from radioactive and nuclear facilities, or those from security forces. Over the years, it evolved under different names, currently adopting the name of Basic Course in Radiation Protection (CBPR). It is a theoretical and practical training that focuses on ensuring that participants reach an adequate level of understanding of the physical phenomena of ionizing radiation and the application of the fundamental principles of radiation protection. It has a workload of 280 hours and is delivered regularly in face-to-face mode during 10 weeks. Within the country, it is recognized as complementary training for personnel who will serve as radiation protection officer in relevant facilities.

Parallel to the first training efforts, agreements were established with the Faculty of Engineering of the University of Buenos Aires (FIUBA) to open, in 1980, the first Postgraduate Course in Radiological Protection and Nuclear Safety. Given its impact both nationally and internationally, the following year it was sponsored by the IAEA, thus becoming the first edition of the training program called PGEC. Building on the success of the model, the IAEA promoted its replication in different regions Coinciding with the publication of the first IAEA Standard Syllabus (IAEASYL-01), the Argentine postgraduate course was divided into the Postgraduate Course in Radiation Protection and Safety of Radiation Sources and the Postgraduate Course in Nuclear Safety. Taking into account the recommendations of IAEA Safety Series No. 115 (1996) and the experiences gained in the courses of Argentina, South Africa, Syria, Malaysia and Belarus, the first revision of the Standard Syllabus (IAEA- TCS-18) was edited (2002). Once again, in 2019, this document was revised and updated to reflect the changes in the IAEA Safety Standards and the conclusions and recommendations of the relevant international organizations and committees in the field of radiological protection and the effects of ionizing radiation. [IAEA-TCS-18 (Rev. 1)]. Always aligned with the IAEA standards, Argentina was adopting the various syllabus published by the IAEA.

After 26 years of experience in education and training, Argentina received the first EduTA mission, aimed at evaluating national capacities for education and training in radiation protection. The satisfactory results obtained from this service led to the sign the Long-Term Agreement (LTA) established between the Argentine Republic and the IAEA, to provide support on a sustained basis, to the Argentine Nuclear Regulatory Authority (ARN) as a Regional Training Center in Latin America and the Caribbean for Nuclear, Radiological, Transportation and Waste Safety (RTC). Currently, there are 9 RTCs in the world, Argentina being the only Spanish-speaking one

In 2013, the Postgraduate Course in Radiation Protection and Safety of Radiation Sources reached the status of a Specialization Career, becoming a postgraduate degree from the University of Buenos Aires. The justification for the introduction of radiological protection in the university environment was based on the need to create qualified and specialized human resources to maintain the level of excellence necessary to effectively develop the extensive nuclear activity that Argentina maintains. These considerations can be extended to countries in the region, even those that decide to undertake new projects.

The Specialization Course in Radiation Protection and Safety of Radiation Sources (CEPRySFR) has the official accreditation of the Argentine organization dedicated to the evaluation of educational quality for the higher level, the National Commission for University Evaluation and Accreditation (CONEAU). During 2020, pandemic in between, the career was presented again before the CONEAU to officialize the mandatory re-accreditation for all postgraduate careers in the country.

This postgraduate educational activity is taught jointly by NRA and FIUBA and is aimed at young professionals who, over time, aspire to become regulators, decision makers, qualified experts in radiation protection or trainers. The degree course has an intensive face-to-face modality, with a duration of 568 hours distributed over 26 weeks. The career consists of 13 subjects designed to provide theoretical and practical training, 6 theoretical seminars and the completion of an integrative final project (TFI). The workload does not include the time devoted to the development and presentation of the TFI required for graduation.

In these 41 years, Argentina trained 1,254 professionals in radiological and nuclear safety (580 Argentines, 655 from Latin America and the Caribbean and 19 from other regions), and a similar number of participants attended the technical training course.

The intensive modality of the course presented by both the CBPR and the CEPRySFR, requires pedagogical strategies to encourage the attentive and active participation of students in face-to-face classes. On average, students receive 6 hours of class per day, 5 days a week, for the duration of the course (11 weeks) or the degree (26 weeks). This modality not only requires the exclusive dedication of the participant, but also multiple tactics so that the student can mature, in such short times, the concepts that will be required in the successive units.

7- Blended-Learning strategies

The pandemic was a surprise event, at least for those of us who did not listen carefully to the warning signs that different social and environmental critics gave in a timely manner. However, as mentioned in another passage, the problems that the pandemic posed to education were not new, but in some way, it updated them.

A wise decisión on our part was to start working very consciously and without any kind of self-compassion, on the weaknesses of our educational program. In this way, under the principle of not relying exclusively on our perception, we elaborated a systematic evaluation mechanism to assess the performance of the degree in all its aspects: from the incorporation of postulants to administrative management, from the design of the study plan, practical activities to the Final Work, among other topics. The intention was to identify with precision the aspects to improve.

The element that ties together a series of drawbacks is the relationship between the contents of the race and its extension over time. This makes it necessary to organize intensive 6-hour classes 5 days a week for 26 weeks. With the intention of improving, at least in part¹⁹, this problem, the RTC began

¹⁹ It is a difficult issue to solve. 50% of the students come from Latin America, awarded by IAEA. To attend this graduate program, students obtain special permission from their companies or agencies. At the same time, the scholarship has a duration of 6 months. With what, despite the multiple updates and modifications that this race adopted, the option of lengthening the total length of the race was never a certain possibility.

working 5 years ago on the implementation of new technologies and educational tools. The strategy consisted in combining distance education methods with face-to-face classes, giving rise to a blended-learning type modality, in order to reduce the amount of daily hours in front of class.

The first step was to put into operation a learning management platform (LMS) -Moodle in our case-, which opened the possibility of incorporating new educational resources. At the same time, we work boldly in the training of the teaching and administrative staff of the RTC, particularly on the use of new technologies. In this way, we promoted three special courses with the collaboration of the IAEA:

- **E-learning Development Workshop** - 7-11 May 2018
- **National Train the Trainers Course for Senior Lecturers in the (PGEC)** - 3-7 Sept 2018
- **Implementation of the new PGEC Syllabus. Introduction of Learning objectives and innovative tools** (2-6 March 2020)

At the same time, it was decided that a member of the career staff should become professional in this field. The purpose of this idea has multiple applications:

- Have suitable personnel to handle the new tools properly.
- Have advice for the incorporation of new technological tools
- Manage possible technical failures that may occur
- Replicate systematic courses for teachers and for the rest of the management staff.

This policy had an immediate impact. Over the course of a year, or little more, all the teachers were able to independently handle the available tools, or, with the collaboration of our professional, project the creation of new audiovisual materials.

That was precisely the second step: the conversion of study materials to digital formats. On the one hand, including audiovisual units permanently available to students, provided the possibility of having materials that can replace - along with other complementary asynchronous activities - hours of face-to-face classes. In other words, this idea collaborated directly with our main objective of reducing the daily face-to-face workload -and thus strengthening the educational quality- with the meeting between teachers and students promoting their active participation. But it also contributed to updating the traditional class format: the teacher's presentation, supplemented with the PPTs, is a very static format, at least for a 6-hour daily class schedule.

This process of converting materials to carry out asynchronous classes, a typical form of distance education, was carried out using highly flexible programs and applications. Some of the most used resources were the production of videos and audiovisual material with Powtoon, Genially, Videoscribe or live recordings (not live) uploaded to YouTube, creation of infographics (using Visme and Canva among others) and production of SCORM packages with Articulate 360. Some teachers also opted for the inclusion of audios in the ppts. It is important to highlight that in order for students to have access to all the material, it was necessary to create virtual classrooms that we carried out through the PLMS LANENT.

The use of this platform was a significant advance. It allowed the centralization of all the information (the didactic material, class attendance, student qualification, etc...) and the full and permanent access by the students. This process clearly strengthens the autonomy of the students, a vital element to be able to develop asynchronous classes.

The joint implementation of these ideas made it possible to build a modest but adequate base for future developments and expansion of the blended-learning modality. And obviously it was what allowed us to continue educational activities during the pandemic.

8 -PGEC during pandemic

The 2020 version of the PGEC was abruptly discontinued. When the pandemic began in our country²⁰, the PGEC was less than a month away from its start. On Wednesday, March 11, in the morning we

²⁰ The Argentine government made the start of the pandemic official on March 20, 2020.

received an official communication from the IAEA stating that we should take the necessary measures so that on Friday, March 13, all foreign students - half of the enrollment - are ready to board the planes with destination to their country. In two days we managed to get most of them to achieve that goal. Of course, with a great collaboration from the IAEA.

At the same time, we put on hold the continuity of the career for Argentine students. The suspension was extended for up to two more weeks, at which point a decision was made to cancel the program for that year.

At the same time, all the personnel of our organization immediately began to carry out their functions on home-office modality. The impact immobilized us, but only for two weeks. In an agile and determined way, we set ourselves two objectives:

- Culminate with the presentation of the degree before the CONEAU for its mandatory re-accreditation.
- Evaluate the possibility of opening the Basic Course on Radiological Protection

While we finished with our obligations with the CONEAU, and with the immense collaboration of all our staff and, particularly, of the professors, we saw that it was possible to launch the first online version of the CBPR. On October 5, having previously passed the participant selection process, our first fully virtualized course was opened, with a duration of 10 weeks. With the precautions that the case allows us, we evaluate that this experience was successful. With the impetus of this first attempt, we immediately set out to evaluate the possibilities of also organizing the PGEC under this modality, if the pandemic continued with its firm step.

After an intense debate carried out by the staff of the E&T Unit, directors of our institution, the professors, the university, and the IAEA, it was decided to open the degree for the month of July 2021. But previously, we reopened the CBPR on May 31. In this version, and for the first time, the course was sponsored by the IAEA at the regional level, awarding scholarships for students.

To achieve our goal of launching the opening of PGEC we had an intense task on multiple fronts. We will summarize the central points to account for this work:

- Our program is formally approved by the University of Buenos Aires under the face-to-face modality. So, the necessary modifications were made to present a program adapted to the new situation. The University, at the same time, had a policy open to proposals in times of pandemic.
- We acquire the minimally essential technologies to be able to offer the PGEC in such a way that it is possible to dictate all the contents of the degree.
- Modification of the career schedule: it was proposed to carry out synchronous and asynchronous theoretical classes for 24 weeks of two hours in the morning and two hours in the afternoon during the year 2021 (from July to December). The possibility that technology grants to adapt study materials and classes, allowed us to reduce the online "face-to-face" hours to 4 a day, lengthening the number of weeks a bit. For 2022 it is planned to carry out practical activities, laboratory practicals and technical visits for 5 or 6 weeks. Since the practices are separated from the theoretical classes, we proposed to do refreshing lectures immediately before each scheduled practice.
- Modifying the format of the classes: from face-to-face to a synchronous and asynchronous interaction. On the one hand, virtualization accelerated the incorporation of asynchronous classes. Most of them have been designed for the student to complete independently, prior to a synchronous class in which these topics will be discussed. In this way, the student reaches the meeting with the teacher having familiarized himself, and even gone through some self-evaluation mechanism, with the subject that he will delve into in the synchronic class. Also, asynchronous classes are primarily based on the material described above (videos, SCORMs, etc.). On the other hand, simulating the classroom space, the synchronous classes are dictated through video conferencing services (via Zoom). In this type of classes, the typical classroom format is usually maintained, in which the teacher's dissertation is complemented with the use of the

blackboard (now virtual), the projection of a ppt and also the organization of groups by means of Zoom.

- At the same time, we have had to adapt countless study materials, prepare asynchronous classes through videos, audios, and other complementary activities, in order to meet the requirements of the curriculum.
- An important element was to record all the synchronous classes. On the same day of class, all students have access to the classes uploaded to our YouTube channel.
- Every day a member of our staff accompanies teachers and students during each synchronous class. With this support, we are able to detect connectivity problems, technology failures, take assistance from students, attend to administrative inquiries from students, among other relevant tasks.
- The adaptation of practical work: obviously it is not possible to adapt to the virtual environment all the practical activities and technical visits included in the curriculum. However, it has been possible to carry out some virtual visits to relevant facilities, with the collaboration of personnel from different organizations and companies. Some of these visits were carried out entirely in asynchronous format, and others synchronously (supported by videos or images). Unfortunately, there are technical difficulties in most of the facilities to carry out visits by streaming. Online simulators have been used to replace labs, and demo videos have been included to replace some others.
- Evaluation of the knowledge incorporated by the students: the online modality raises a key problem that keeps us attentive particularly to guarantee educational quality. We have implemented several exam formats, changing the modality by subject: calculation of real times to carry out the exams with questions appropriate to this requirement, randomly ordered questions, exams via PLMS + ZOOM with open camera, as examples.

To finish this long article, it is important to consider some problems that we have detected. However, we will be able to have a more precise evaluation of the performance of the PGEC when we culminate with the analysis of the self-evaluation process that we usually carry out, and that was adapted in this version due to its particularities.

So far we were able to perceive three central problems:

- Despite having informed during the participants selection process that our educational program requires exclusive dedication, the students were unable to meet this requirement and continued with attending their job. Probably, their job requirements did not allow them to achieve this objective, which we understand will negatively affect the educational performance of the students, and consequently on the quality of the teaching-learning process. We need a greater commitment from the institutions that send their staff to our program.
- The implementation of certain technological tools (in particular Zoom) prevented the incorporation of students from some countries since the applications of this company are not used there
- Just as virtualization can increase the number of people interested in courses and careers, there are various technological problems that can cause a decrease in the number of participants: the lack of stability in Internet connections, or the lack of access to certain software resources.

We are fully aware that in the course of the degree and with the help of the analysis of data from the implemented survey, other multiple problems will arise on which we will have to work particularly. We have the intuition that the monitoring of the formative evolution of the students will be one of them. It is also likely that some discomfort is expressed with the mode of interaction between the participants.

However, the updating of old educational problems that the pandemic brought us also presents an opportunity to re-signify the use of new technologies in order to improve the teaching-learning process.

Argentine Radiation Protection Young Professionals Network (RedSARJoven). Engaging the New Generation

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Argentine Radiation Protection Young Professionals Network (RedSARJoven) Engaging the New Generation

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Abstract. Since its creation in 1965, the Argentine Radiation Protection Society (SAR) is working to fulfil the foundational objective of promoting knowledge on radiation protection through training, dissemination of information and knowledge management. This is why SAR carries out the regular dictation of courses recognized by the competent authorities and also special courses.

In recent times, it has become clear that the young generation has a different way of communication and learning. It is a real challenge to adapt the education and training in radiation protection to the modern world, a technological world, where information is extremely wide and where there are many ways to share knowledge and experiences. Thinking on the needs of the Radiation Protection Young Generation, SAR decided to launch the Argentine Radiation Protection Young Professionals Network (Red SAR Joven). This network was created with the purpose of promoting the participation and inclusion of young professionals working in radiation protection in all its applications, improving the resources of the human capital and its competences and promoting the culture for safety in the new generation.

Red SAR Joven was launched at the IYNC-WIN 2018 Congress (International Youth Nuclear Congress - WIN Global Annual Conference) in March 2018, in Bariloche (Argentina) at the Panel “Youth in Nuclear Energy - A Nuclear Movement”, where the perspective of young professionals working in nuclear energy and radiation protection were presented by leading professionals from international organizations. One of the main objectives of Red SAR Joven is to create a space for the exchange of ideas and joint work among the young professionals working in radiation protection and also to encourage young professionals who start in this area, giving them information about the different opportunities. To fulfil this objective, and taking advantage of the extensive experience of elder members of SAR, Red SAR Joven is planning to launch a Mentoring Program for knowledge transfer, exchange of experiences and fundamentally to guide young professionals in their radiation protection career development.

During the 2018-2020 period, Red SAR Joven has organized different activities for young professionals, as a “Workshop on Radiation Measurement” and a “Workshop on Optimization Applied to Medical and Industrial Practices”. Representatives of the network had participated in national, regional and international events, such as the XI Latin American Regional Congress in Havana – Cuba, with the aim of sharing the experience in the region and encouraging the creation of national networks in other countries.

Red SAR Joven is in line with IRPA's goals that promote the participation of young professionals, as well as being part of the global youth movement in all areas, from nuclear energy to medical applications, from industry to education, research and communication.

KEYWORDS: *Communication, Young Professionals Network, New Generation.*

1 INTRODUCTION

Argentina has developed experience in the nuclear field since 1950 to obtain the benefits from the peaceful uses of nuclear technology. This long experience is the reason why Argentina has a strong position in the world today, with the development of new technology and new projects, from nuclear power plants, production of radioisotopes and all the applications of nuclear technology like nuclear medicine.

From the beginning, the country has worked on radiation safety along with nuclear developments; taking into account the safety of the workers, the public, the patients and the environment. There are highly qualified human resources and experience, and in this sense, the country has the challenge to transfer knowledge to the young professionals and motivate the new generations to work in this scientific field.

The Argentine Radiation Protection Society (SAR) since its creation, in 1965, has been working to fulfil the foundational objectives: to promote the execution of works and exchange of expertise in radiation protection and related issues, to promote awareness of radiation protection principles in regard to the existence and use of radioactive material and sources of radiation and to promote radiation protection as a professional expertise and to contribute to its progress.

One of the main objectives of SAR is to support the active participation of young professionals in radiation protection events. Since its creation in 2013, our Argentine colleagues participated of the Young Professionals Awards in Latin America and the Caribbean, in every IRPA Regional Congress (Brasil, 2013; Argentina, 2015; Cuba, 2018). SAR also supports the participation of young professionals in the Young Scientists and Professionals Awards in International IRPA Congresses (South Africa, 2016; Korea, 2021). In the last national congress, in 2019, SAR organized a special session of young professionals with the presentation of works in different areas.

The participation in IRPA Congresses and these important awards have motivated and contributed with the new generation professional development in radiation protection. The events are a great opportunity to establish networking between young colleagues at regional and international level.

2 CREATION OF THE YOUNG PROFESSIONALS NETWORK



In 2018, SAR decided to create a network for young professionals in Argentina (Red SAR Joven) [1], in line with IRPA initiative, as well as being part of the global youth movement in all areas, from nuclear energy to medical applications, from industry to education, research and communication.

At this moment the network has more than 50 members who participate in different activities and exchange information and receive news by e-mail.

This network was created with the purpose of:

- encouraging the participation and inclusion of young professionals working in radiation protection in all its applications,
- improving the resources of the human capital and its competences and
- promoting the culture for safety in the new generation.

The goal is to have a common space to: exchange ideas and work together, make questions and receive answers, show the work of the members and share news (like congresses, courses, scholarships, publications, and of course all kind of information of interest for the young generation).

Red SAR Joven was launched at the IYNC-WIN 2018 Congress (International Youth Nuclear Congress - WIN Global Annual Conference) in March 2018, in San Carlos de Bariloche (Argentina) at the Panel “Youth in Nuclear Energy - A Nuclear Movement”, where the perspective of young professionals working in nuclear energy and radiation protection were presented by leading professionals from international organizations.

In the same year, in April 2018, the Network was presented in the last IRPA Regional Congress that was held in Havana, Cuba, with the aim of sharing the Argentine experience and encouraging societies of all Latin America to take this initiative and to launch their own Young Professional Network.

3 SOCIAL MEDIA

In recent times, it has become clear that the young generation has a different way of communication and learning. It is a real challenge to adapt the education and training in radiation protection to the modern world, a technological world, where information is extremely vast and there are many ways to share knowledge and experiences.

The page in Facebook @RedSARJoven was created at the same time as the Network creation in January 2018. On the page, updated news can be found like activities, publications, congresses, workshops, fellowships and other information of interest for the young generation in radiation protection. Currently, the page has 530 followers.

More recently, the use of Instagram has risen a lot particularly among young people. Last November, the account @RedSARJoven was created and launched in the “Virtual workshop on radiation protection in radiology”. In only one month, the account reached over 100 followers.

As a result of the first virtual workshop organized by the Network, a You Tube Channel “Red SAR Joven” was opened to share some videos of the Network Activities and make the information available, in particular for those who couldn’t participate in the activities in real time.

4 WORKSHOPS

Among the activities that have been organized and carried out by Red SAR Joven during 2019-2020, it can be mentioned three workshops. It is important to highlight that all the proposals were suggested by the members. The registration was free of charge with the aim of increasing the participation of young professionals.

4.1 Workshop on Radiation Measurement – March 2019

The Workshop on Radiation Measurement was carried out from 20 to 25 March, 2019, with 32 participants. The goals were to provide training and updating in the use of detectors and measurement techniques with dose rate and surface contamination detectors. The participants were young professionals coming from different areas and it was required to have previous basic knowledge on radiation protection. The participants work in a variety of applications and institutions, for example: universities, investigation laboratories, regulatory authority, research reactors, hospitals, waste management facilities and fire brigades.

During four days, theoretical and practical sessions were held, including the use of different types of detectors and sources of low activity. The last day, a practical exercise was carried out visiting a relevant facility where the participants had the opportunity to interact with the staff. At the end of the workshop, the participants continued working in groups for data analysis and conclusions of the measurements collected.

4.2 Workshop on Optimization Applied to Medical and Industrial Practices – August 2019

The Workshop on Optimization Applied to Medical and Industrial Practices was carried out from 28 to 30 August, 2019, with 22 participants. The goals were to provide training and updating to young professionals who work in radiation protection in industrial and medical areas for the implementation of optimization.

During three days, the optimization basis, ALARA approach and procedures were presented based on the Safety Report No.21 Optimization of Radiation Protection in the Control of Occupational Exposure – International Atomic Energy Agency. Each day, practical cases were presented that reflected situations in different areas: nuclear medicine, radiodiagnostic, interventionism, industrial radiography, research reactors and PWR.

The last day, a method to help decision making was presented. At the end of the workshop, the participants created a WhatsApp group to ask questions and interchange information and news. The group is currently active and contributes to the aims of the Network.

4.3 Virtual Workshop on Radiation Protection in Radiology – November 2020

The Workshop on Radiation Protection in Radiology was carried out on November 7, 2020, with more than 150 participants from Argentina, different countries of Latin America and also Portugal. The proposal was made to celebrate the International Day of Radiology (November 8). This workshop had the additional challenge that the lectures were all given by young professionals that work with radiation in different areas.

At the end of the workshop, a panel was organized to discuss: How to enhance radiation protection and How to strengthen and motivate the young generation. Some conclusions: keep working and give opportunities to young students and professionals; strengthen the use of social networks as the main way of communication today; and plan strategies to encourage the next young generation or generation Z.

The workshop recording was recorded and uploaded in the new You Tube Channel of the Network [3].

5 PUBLICATION IN NUCLEAR JOURNAL

In 2018, after the launched, Red SAR Joven published an article in the nuclear journal “EN hoy” [3] of national distribution with the aim of promoting the Network and also the activities regarding radiation protection.

6 WOMEN IN RADIATION PROTECTION

The Network has an active participation and a strong commitment by young women who work in radiation protection in different fields: such as research, dosimetry, waste management, research reactors, nuclear medicine, etc.

Red SAR Joven widely disseminated information about the IAEA Marie Sklodowska-Curie Fellowship Program and encouraged young women to participate as an opportunity to improve their education and training.

Red SAR Joven hopes to encourage women to work in radiation protection and inspire the younger generations.

7 PARTICIPATION IN IRPA YGN

From the beginning, Red SAR Joven is a member of the IRPA Young Generation Network (YGN) [4]. Since 2020, the chair of Red SAR Joven has the honor and pleasure of being a member of the Leadership Committee.

In 2020, as being part of the IRPA YGN, Red SAR Joven collaborated in the collections of testimonies on the impacts of the Covid-19 on the continuity of RP. Argentina participated in the collection of them and in the translation into Spanish of the synthesis. Currently, the synthesis is available in English, Spanish, Japanese and German [4].

8 BOOK: HISTORY OF SAR

In 2019, SAR edited the book of the “History of Argentine Radiation Protection Society, 1965-2018” [6]. The book was made with the contribution of testimonies and documents given by many members and with the hard work as compiler by the Member N° 1 of SAR.

Red SAR Joven is very grateful to be included in the Chapter 14. It’s like a symbolic bridge and hope to continue with the activities and write the next edition.

9 CONCLUSION

The creation of Red SAR Joven provides a common space for young students and professionals in radiation protection. The activities carried out contribute to the development of the professional career considering technical skills as well as soft skills (communication, teamwork, leadership).

Red SAR Joven hopes to be a reference and guide for the young generation, who have the legacy and challenge to continue with the goals of Argentine Radiation Protection Society (SAR), to improve and to strengthen the radiation protection in all its applications.

10 ACKNOWLEDGEMENTS

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30 Years of ABACC: the Role of State Authorities in Supporting its Activities

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30 YEARS OF ABACC: THE ROLE OF STATE AUTHORITIES IN SUPPORTING ITS ACTIVITIES

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ABSTRACT

The confidence-building process between Argentina and Brazil during the 1980s led to the signature of a unique safeguards' agreement in July 1991: The Agreement between the Republic of Argentina and the Federative Republic of Brazil for the Exclusively Peaceful Use of Nuclear Energy. This "Bilateral Agreement" incorporated all the nuclear commitments already made by both countries and established the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC), a binational organization aimed at the management and implementation of the Common System of Accounting and Control of Nuclear Materials (SCCC). Particularly, the "Bilateral Agreement" establishes that Argentina and Brazil "shall make their technical capabilities available to the ABACC in support of its activities". In this regard, the role of the State Authorities responsible for safeguards implementation in Argentina and Brazil is crucial. In the year of ABACC's 30th anniversary, the paper summarizes the experience of the Nuclear Regulatory Authority (ARN) of Argentina and the National Nuclear Energy Commission (CNEN) of Brazil in supporting ABACC activities during the past decade (2011-2021).

1. Introduction

This paper does not intend to address the historical process that led to the creation of the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC), a subject thoroughly analyzed by academics and key actors [1], nor details about its link with the Agreement between the Republic of Argentina, the Federative Republic of Brazil, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials and the International Atomic Energy Agency for the Application of Safeguards [2] ("Quadripartite Agreement"). Rather, it focuses on the framework of the Agreement between the Republic of Argentina and the Federative Republic of Brazil for the Exclusively Peaceful Use of Nuclear Energy [3] ("Bilateral Agreement") and in particular on the role that national safeguards authorities play within it.

It is important to emphasize the high-level political will behind the negotiations on the establishment of the ABACC, considering that the initial intention was the establishment of a cross control system. Argentina and Brazil developed the Common System of Accounting and Control of Nuclear Materials (SCCC), exchanged declarations of their respective States' initial inventories and even did one inspection in the other State's facilities. Nevertheless, with the aim of achieving transparency in the nuclear activities developed by both countries there was the decision to create an external body to implement this control. Therefore, following the construction of their bilateral relations, and after a series of relevant nuclear commitments during the 1980s Argentina and Brazil signed a unique safeguards' agreement in July 1991. Ratified only 5 months later, this "Bilateral Agreement" established the ABACC, with the mission of managing and implementing the SCCC.

Particularly, the "Bilateral Agreement" stated that Argentina and Brazil "shall make their technical capabilities available to the ABACC in support of its activities". In this regard, the

role of the State Authorities responsible for safeguards implementation in Argentina and Brazil is crucial.

In the year of ABACC's 30th anniversary, the paper summarizes the experience of the Nuclear Regulatory Authority (ARN) of Argentina and the National Nuclear Energy Commission (CNEN) of Brazil in supporting ABACC activities during the past decade (2011-2021).

2. The SCCC and the ABACC

In order to guarantee Argentina, Brazil and the international community that all existing nuclear material and facilities under their jurisdiction or control are used exclusively for peaceful purposes, this being the basic commitment that the countries assume, the "Bilateral Agreement" establishes the SCCC.

The SCCC is "a set of procedures established by the Parties to detect, with a reasonable degree of certainty, that the nuclear materials present in all their nuclear activities are not diverted to nuclear weapons or other nuclear explosive devices, in accordance with the terms"¹ of the present Agreement. For its administration and application, the Agreement creates the ABACC and institutes for it two bodies: the Commission and the Secretariat.

The Commission, the governing body, consists of four members, two of them appointed by each Government. Currently the Commission is composed of the presidents of the national safeguards' authorities (the Nuclear Regulatory Authority of Argentina and the National Nuclear Energy Commission of Brazil) and representatives of the foreign ministries (Director of the Department of Defense and Security Affairs for Brazil and the Director of the Directorate of International Security, Nuclear and Space Affairs for Argentina).

The Commission is responsible for supervising the functioning of the Secretariat, appointing its professional staff, preparing the list of inspectors from among those proposed by the Parties to carry out the inspection tasks entrusted to them by the Secretariat, and requiring the constitution of ad-hoc advisory groups, as needed. In addition, before the governments of Argentina and Brazil, it must report annually on the application of the SCCC and inform the Parties of the non-compliance by one of the Parties of the commitments made under the Agreement..

For its part, the Secretariat is the executive body that develops the activities necessary for the application of the SCCC and represents the ABACC before the national authorities of both countries and before third parties. The Secretariat is made up of professionals appointed by the Commission and auxiliary staff. The senior officers are the secretaries, one of each nationality, who rotate annually in the performance of their duties as Secretary and Deputy Secretary.

In structural terms, besides the administrative auxiliary personnel, it is organized into six sectors: Planning and Evaluation, Operations, Nuclear Materials Accounting, Technical Support (all made up of two officers, one of each nationality), and Institutional Relations and the Administrative-Financial sectors that are occupied by a single officer.

It is important to note that, in the fulfillment of their duties, the professional officers of the ABACC do not represent or are part of the governmental structures of either of the two countries and cannot request or accept instructions from any government or from any authority outside the ABACC. In other words, their responsibilities are exclusively international.

In the same way, in the fulfillment of their missions, the inspectors are also international officers, and they undertake to regulate their conduct taking into account only the interests of the ABACC.

3. Support from national authorities to ABACC activities

¹ Art 1., Annex of Agreement Between the Republic of Argentina and the Federative Republic of Brazil for the Exclusively Peaceful Use of Nuclear Energy, INFCIRC No. 395, IAEA, Vienna (1991).

The Nuclear Regulatory Authority (“Autoridad Regulatoria Nuclear”) –ARN- and the National Nuclear Energy Commission (CNEN) are the State Authorities responsible for safeguards implementation (SRA) in Argentina and Brazil respectively.

In 1997 the National Nuclear Activity Act [4], established ARN as an autonomous and independent body within the jurisdiction of the Argentine Presidency, empowered to regulate and control all nuclear activities in the country, with competence on four branches: radiological and nuclear safety, physical protection, safeguards and nuclear non-proliferation.

The Nuclear Regulatory Authority, as SRA, has the goal of ensuring that nuclear activities are carried out exclusively for peaceful purposes. Particularly, it established the guidelines of the State System of Accounting for and Control of Nuclear Material (SSAC) in Argentina [5] and the relevant safeguards requirements and procedures, in line with the international agreements on safeguards and non-proliferation. To verify the compliance of licensees, the ARN performs regulatory controls through its own body of inspectors and analysts and to enforce their compliance it has the power of applying sanctions.

Within this legal framework, the ARN has the appropriate authority to exercise safeguards oversight and control over all nuclear material and activities in Argentina.

Particularly, safeguards-related activities are coordinated and performed by two areas within the ARN: the Non-Proliferation Policies Division and the Control of Safeguards and Physical Protection Division.

The Brazilian Nuclear Energy Commission (“Comissão Nacional de Energia Nuclear”) - CNEN- is an independent federal organization created in 1962 by Law 4.118 [6], complemented with law 6.189 [7], with the main objectives and obligations of participating in the definition of the national nuclear energy policies, carry out the research, development, promotion and services in the area of nuclear technology and its application for peaceful purposes and regulating, licensing, authorizing and controlling nuclear and radioactive materials and installations in Brazil. According to Article 21, XXIII(a) of the Brazilian Federative Republic Constitution, enacted on 5 October 1988, all nuclear activity in national territory will only be admitted for peaceful purposes and upon approval of the National Congress.

In the context of the above CNEN as a regulatory body is the responsible for controlling all nuclear material and nuclear installations and represents Brazil in the implementation of international safeguards agreements signed by Brazilian Government. Since May 2021, the process of separation between regulatory and research and promotion functions in the nuclear area is underway. The regulatory agency was created by a decree of the Brazilian Presidency [8] and is now under approval by the Brazilian Congress.

The regulatory basis for nuclear material control and safeguards was established in 1982 by the Regulation CNEN-NN-2.02 of April 1982, revised in September 1999 [9] and complemented by the on line e-Gamma System [10], approved and published in Brazilian Federal Register in 2013, for use by the facility operators in real time, to request CNEN the authorization for nuclear material transfers and for other inventory changes, for records keeping and CNEN approval and authorization, as well as for auditing by ABACC and IAEA.

As pursuant to Article XVI of the Bilateral Agreement, ARN and CNEN make their technical capabilities available to the ABACC in support of its activities. They also play an important role with respect to the joint implementation of safeguards by the IAEA and ABACC.

3.1. Human capital

Throughout the 30 years of its existence, the national authorities have contributed to the ABACC with their human capital, not only because of the commitment assumed by the governments and thus manifested in the Bilateral Agreement, but also because of their conviction.

Both organizations, based on the profiles and areas of knowledge of their personnel, contribute with experts to participate in specialized ad hoc groups of the ABACC; places at ABACC's disposal agents with training in safeguards and with experience in nuclear verification at the national level to integrate the body of inspectors that, during the exercise of their functions, depends exclusively on the ABACC. Historically, the ARN and the CNEN have been the areas in which an immense majority of the officers of the Secretariat have developed their careers, as is the case of the current secretaries of the ABACC.

Differently from the professional officers and administrative staff, the inspectors are not permanent ABACC personnel, but rather a group of professionals, designated as inspectors by the Parties, and selected by the Secretariat to work for the ABACC on a temporary basis to carry out verification activities.

It should be noted that one of the strengths of the inspection system lies in its highly specialized body of inspectors with a deep knowledge of the idiosyncrasies and socio-economic and political conditions of the region [11]. This body contemplates a wide variety of profiles, both in terms of academic training and specialization in the nuclear field, as well as in the tasks that they carry out on a daily basis in their institutions of origin.

On the one hand, the list is made up of technicians and professionals from the area of research, development and promotion of nuclear energy from both countries, including state agencies, universities and companies that operate laboratories, nuclear fuel cycle facilities and nuclear power plants. From this role, beyond being specialists in the different types of nuclear facilities, they are usually familiar with and/or receiving inspections from the ABACC and the IAEA, which represents "the opportunity to better understand both sides of the system, to be constantly informed of advances in both areas and, especially, understand the importance of implementing adequate control of nuclear materials and apply these concepts more efficiently in their routine work [12]".

On the other hand, the ABACC has inspectors, whose institution of origin are the national safeguards authorities of Argentina and Brazil, with experience in accounting and control of nuclear materials and specific training and practice in the field in the development of national inspections in their countries. For these national inspectors, the possibility of acting as regional inspectors represents an important step in their professional career paths and for the national authorities a more experienced staff with a broader level of understanding of the nuclear facilities in the region.

This list is completed by retired personnel, without a current formal link with national institutions or organizations. In addition to the fact that ABACC can take advantage of all their years of experience in the field, they have the benefit of having immediate availability to carry out inspections. Also, some of them are consulted as advisers for certain issues.

It should be noted that ABACC officials can also carry out inspections, but for this they must be part of the list of inspectors of the ABACC.

The other strengthening element of the system, thus recognized internationally, is the scheme of cross inspections known as "neighbors watching neighbors" [13], through which inspectors of Brazilian nationality inspect facilities under the jurisdiction of Argentina and vice versa.

Currently, the Secretariat has a list of 97 inspectors, 46 of Argentine nationality, 51 of Brazilian nationality, of which 26% are women and 31% come from the CNEN and the ARN, which shows the importance that the national safeguards authorities assign to this work and to the maintenance of the inspectorate of the bilateral system.

3.2. Coordination

During the past ten years, the plans in the nuclear field in ABACC area have expanded and materialized through the execution of different projects of considerable magnitude. In the area of reactors it is worth mentioning the construction of the CAREM 25 Modular Reactor, near

Buenos Aires, the first SMR under construction in Latin America and of the LABGENE Reactor, in São Paulo area, the prototype of the future Brazilian naval propulsion nuclear reactor, and the development of the projects in Buenos Aires, of the RA10 Research Reactor and, in São Paulo, of the Multipurpose Reactor, both setting a standard for scientific development in the region, in addition to its capabilities for the production of radioisotopes for industrial and medicinal purposes. In addition, a dry storage for irradiated fuel assemblies entered into operation in the site of the Angra Nuclear Power Plants and the 8th Cascade of Module 3 start operation in the Resende Enrichment plant of Brazil. Aa new uranium dioxide conversion plant in the province of Formosa, dry storage projects for irradiated fuel elements and new nuclear power projects are in advanced feasibility study in Argentina.

As Argentina and Brazil deepen and increase their nuclear development, new facilities are included under ABACC's safeguards. This implies new challenges in terms of how to interpret the principles for the application of safeguards and the coordination of their efforts for their effective control, such as the carrying out of inspections.

Currently in ABACC area there are 75 facilities and LOs under safeguards in Argentina and Brazil and 220 annual inspections are carried out, on average, between national and international inspections. All of them are coordinated well in advance according to the operational schedule provided by the operators.

The regulatory authorities of Argentina and Brazil coordinates, respectively, the international inspections with ABACC and IAEA and the facility operators, participate in the pre-inspection meetings and in all the inspection activities in the field.

3.3. Cooperation

This section refers to the cooperation of the national authorities, directly and indirectly, with the ABACC.

Argentina and Brazil regulatory authorities have, respectively, a Cooperation Protocol in force since the 1990s [14], revised in case of CNEN in 2013 [15], with the objective of promoting collaboration, for example, in safeguards techniques, laboratories, equipment and other services of mutual interest.

One of the most traditional cooperative activity under this framework consists of the joint provision of training on non-destructive assay (NDA) for safeguards applications to ABACC inspectors. The training, carried out in ARN's [16] and CNEN's safeguards laboratories, covers subjects such as NDA techniques and equipment, operational procedures for equipment, software and measurements, ABACC/IAEA joint use procedures for common use of equipment, good practices and measurement acceptance criteria, and a regular training for ABACC and IAEA inspectors in procedures for unannounced inspections, in which part of the training is held at the Brazilian enrichment facility.

It is worth mentioning that this cooperation has always benefited both sides. Regarding education and training, for example, since most ARN and CNEN inspectors also serve as regional inspectors, they benefit from the ongoing training carried out for ABACC inspectors and the knowledge and skills that they experience as ABACC temporary staff during these trainings also improve their capacities as national inspectors. This ultimately strengthens the national safeguards systems of both countries, and these solid national systems have a positive impact on the tasks carried out by ABACC in compliance with its mission.

In addition, both ARN and CNEN maintain a strong connection with relevant foreign institutions to foster collaboration on safeguards matters. These have represented an opportunity of cooperation with the ABACC and the promotion of the regional safeguards implementation. of the ABACC. In this sense, and as part of the activities developed under the Agreement between, respectively, ARN and CNEN and the Department of Energy of the United States, the regulatory authorities encourage the participation and involvement of the ABACC which, in turn, also has a cooperation agreement with the DOE.

For example, it is worth highlighting ABACC's role in the five-day training course on statistical methodologies for safeguards applications that was held in Buenos Aires in August 2018, covering measurement models, variance propagation techniques, statistical concepts in enrichment measurements, destructive analysis, sampling variability, neutron measurements, holdup and waste measurements, material balance evaluation, measurement errors, MUF, shipper/receiver difference and nuclear material measurements at the ABACC [17].

Also, ABACC contributed with its experience and delivered a presentation on "ABACC Safeguards Regional System: Experience and Cooperation" at a workshop on domestic safeguards inspections for countries in the Americas, attended by participants from eight countries and IAEA officers.

3.4. Technical activities

Argentina and Brazil have developed, with the support of ABACC, technical solutions to challenges in the implementation of safeguards that, in some cases, have had an impact beyond the regional scope.

A concrete example of these developments, which represents a relevant contribution to the international community for the more efficient application of safeguards, is the uranium hexafluoride (UF₆) sampling method for the determination of enrichment, called "ABACC-Cristallini" [18].

This method for safeguards purposes promoted by ABACC presents benefits compared to the traditional method, including the reduction of the amount of nuclear material collected, thus minimizing costs, and facilitating the transport of samples [19].

From the beginning and during the validation process, ABACC had the constant support of the States, in terms of their technical and human capacities, and the commitment of the national authorities through their national support programs to IAEA safeguards.

It should be noted that the ABACC-Cristallini method achieved in 2019 the certification of the American Society for Testing and Materials (ASTM) for its use in nuclear facilities around the world and, within the framework of the Member State Support Programme (MSSP), the IAEA is testing the method in enrichment facilities of other countries that have expressed their interest in applying it. An important development was implemented by CNEN this year 2021, by providing ABACC and IAEA with the opportunity to collect samples from the process lines of the Enrichment Plant of Industrias Nucleares do Brasil (INB), using the ABACC-Cristallini Method, for further chemical and isotopic analysis and confirmation of the method reliability.

It is also worth mentioning the adoption of devices such as the Laser Curtain for Containment (LCCT), in the Dry Storage of Irradiated Fuel Elements of the Atucha I Nuclear Power Plant in Argentina, developed with the support of ABACC, based on the need to have a dual containment system for this new Building. For this, Argentina put its technical capacity and facilities at the service of ABACC for the technical validation of the LCCT [20] [21].

4. Conclusions

In the year of ABACC's thirtieth anniversary, there is no doubt about the degree of maturity that it has reached, together with international recognition as an agency with technical solvency and equipped with duly qualified and experienced staff. It should also be recognized that the State Authorities responsible for safeguards implementation in Argentina and Brazil have played an important role in supporting ABACC activities along the way.

The regional safeguards system between Argentina, Brazil and ABACC has reached considerable technical maturity both in the use and development of new methodologies as well as in the training of its human resources.

However, due to the development of the nuclear plans of Argentina and Brazil, new challenges are envisaged that will demand creativity and innovation in the definition of the control criteria to be applied.

During the next few years, challenges in the application of regional safeguards must be addressed, such as the multipurpose reactors in both countries, CAREM 25 Reactor and the LABGENE Reactor.

Other aspects that should be considered are the decommissioning of facilities, the incorporation of new safeguards technologies, generational change and knowledge transfer.

In this sense, the constant support of the national authorities, as part of the sustained commitment of both States over time, will continue to be a central element of the success of ABACC in its function of guaranteeing the peaceful use of nuclear materials in the region.

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Internal Dose Assessment in Occupational Unexpected Exposure to Xe-133 and Xe-135

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INTERNAL DOSE ASSESSMENT IN OCCUPATIONAL UNEXPECTED EXPOSURE TO Xe-133 AND Xe-135

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Abstract. Following an unexpected exposure to high concentration of noble gases in which a reactor's worker was immersed during some minutes, internal dose assessment was required although the readings of the personal dosimeter were not significant. This requirement arose as a result of having obtained positive values of Xe-133 and Xe-135 in the thorax monitoring performed on the worker from a few hours to several days after the event. As the dose estimation methodology for these noble gases considers only external exposure, the requirement of internal dose evaluation was a challenge since no biokinetic models or dose coefficients of reference for occupational intake of these isotopes were available, in addition to the need for a rapid result of the dose estimation.

The intakes of the xenon isotopes were estimated from the reconstructed concentration of gases at the time of the event. Using the thorax measurements and the estimated intakes, it was observed that the measurements of internally deposited xenon were reasonably consistent with the behaviour of retained xenon in systemic tissues mainly in fat, observed in subjects and in model predictions found in literature. The Xe-133 dose factors recommended by ICRP 128 for patients treated with this radionuclide by re-inhalation of the gas for 10 minutes were considered for this scenario. For taking into account the dose contribution for Xe-135 inhalation, MIRD methodology was implemented. Additionally, positive results of HTO and I-131 in urine bioassays were evaluated using the biokinetic models recommended for the worker, under the assumption of acute inhalation and no contribution from previous intakes of these radionuclides. It was estimated a value of the committed effective dose for inhalation of Xe-133 and Xe-135 of ~0.2 mSv, and considering the contribution of HTO and I-131, it was obtained a total committed effective dose of ~0.3 mSv.

KEYWORDS: *committed effective dose, xenon, unexpected exposure*

1 INTRODUCTION

The xenon isotopes can be produced as fission products during reactors operations and are considered in the group of the least radiotoxic nuclides in internal exposure scenarios [1]. The international recommendations and national standards [2, 3, 4] point out that the external radiation dominates their occupational exposure and provide cloud immersion dose coefficients (Sv.Bq^{-1} per Bq.m^{-3}) that mainly arise from external irradiation and assume that the doses from the absorbed inert gases are negligible.

Because the dose estimation methodology for these noble gases considers only external exposure [2, 3, 4], the need of an internal dose estimation following an unexpected exposure to high concentration of noble gases implies a challenge to internal dosimetry services to perform it without biokinetic models or dose coefficients of reference for occupational intake of these isotopes.

This work describes the actions and the methodology implemented to estimate the total committed effective dose in a reactor's worker who was immersed for some minutes in a cloud of high concentration of gases, despite the worker's personal dosimeter-readings had not been significant. The chronological order of actions to reconstruct the airborne concentration, the intake and the committed effective dose are presented. This work also describes the methodologies implemented to estimate the contribution to the total effective dose from the

internal exposure to Xe-133, Xe-135, HTO and I-131, due to positive results of total body and urine monitoring of these radionuclides in the worker.

2 DESCRIPTION OF THE ACTIONS

During the early morning hours of 17 July 2019 a radiation protection officer of an Argentine reactor decided to send a worker to perform a maintenance task with the suitable protective equipment for aerosols. Although a gas and aerosol leak was not expected, high concentrations of them were recorded in other area that night, so the officer decides to send the worker with adequate protective equipment to prevent aerosol inhalation. It was considered that the inhalation of noble gases was not going to be significant, and if it was the case, the internal dose would be negligible based in the safety standards [2, 4].

At 12:30 a.m. the worker entered the controlled area. One hour later, performing a specific task that lasted 7 minutes, his EPD dosimeter alarm activated with a dosimeter peak reading of 5000 $\mu\text{Sv}\cdot\text{h}^{-1}$ for beta irradiation. Simultaneously, a system (KLK 90) located one floor above measured a peak of 6 DAC of HTO in the environment during the time that the task last.

After decontamination, the worker was unable to exit through the portals; therefore, his total body measurement was programmed. Xe-133 and Xe-135 were detected in his thorax by measuring him with an Accuscan detector around 10 hours later. The internal dosimetry service of the facility established a special monitoring comprised of successive *in vivo* and *in vitro* measurements in the following days. The results of the measurements are presented in Table 1.

Table 1: Results of *in vivo* and *in vitro* measurements made to the worker

Date	Time	Measurement of total body retention of Xe-133 $\pm 1\sigma^{(a)}$ (Bq)	Measurement of total body retention of Xe-135 $\pm 1\sigma^{(a)}$ (Bq)	Measurement of urine excretion of I-131 $\pm 1\sigma^{(a)}$ (Bq, l ⁻¹)	Measurement of urine excretion of HTO $\pm 1\sigma^{(a)}$ (Bq, l ⁻¹)
July 17	09:11 a.m.			$6.0 \times 10^1 \pm 1.2 \times 10^0$	
	09:57 a.m.				$8.88 \times 10^4 \pm 1.8 \times 10^3$
	12:10 p.m.	$3.47 \times 10^4 \pm 2.0 \times 10^3$	$2.05 \times 10^3 \pm 2.8 \times 10^2$		
July 18	10:31 a.m.	$3.68 \times 10^3 \pm 2.5 \times 10^2$	$3.2 \times 10^1 \pm 1.8 \times 10^1$		
	11:00 a.m.			$1 \times 10^1 \pm 0.2 \times 10^0$	
	02:13 p.m.	$1.91 \times 10^3 \pm 1.7 \times 10^2$	<LOD ^(b)		
	03:28 p.m.	$1.83 \times 10^3 \pm 1.6 \times 10^2$	<LOD		
	03:37 p.m.	$1.91 \times 10^3 \pm 1.6 \times 10^2$	<LOD		
	04:11 p.m.				$8.88 \times 10^4 \pm 1.8 \times 10^3$
July 19	12:55 p.m.	$5.33 \times 10^2 \pm 1.6 \times 10^2$	<LOD		
July 20	04:36 p.m.	<LOD ^(b)	<LOD		
July 24	11:57 a.m.	<LOD	<LOD	<LOD ^(b)	$5.85 \times 10^4 \pm 1.2 \times 10^3$

^(a)Activity uncertainty quoted at 1 sigma

^(b)LOD: Limit of Detection, for Xe-133= 10 Bq, for Xe-135=20 Bq, I-131=0.1 Bq.l⁻¹

At 9 a.m. of July 17 an open valve was discovered and gases concentrations were measured in the place where the worker was exposed. In Table 2 are presented the results of gases concentrations measured around 8 hours later the peak of the gases released was detected.

Due to the fact that the concentration of gases at the moment of the event was unknown and there were not biokinetic models for the radionuclides detected in the worker, neither in GSR

part 3 nor in the ICRP reports [4, 5, 6] that explains the retention of Xenon in the thorax, the radiation protection area of the facility did not have enough information to assign an internal dose to the worker. For this reason, a formal request for assistance was sent to the Argentine Nuclear Regulatory Authority (ARN) on 19 July, where independent bioassays and dose assessments were asked. A venous blood sample from the worker was taken for biological dosimetry analysis in ARN Biodosimetry Laboratory, reporting on 26 July an average dose received in the whole body $<0.1\text{Gy}$

Table 2: Results of gases concentrations registered around 8 hours after the peak of the gases released was detected. Dose coefficients and the physical half-life of each radionuclide detected are also presented [4].

Radionuclide	Concentration [Bq.m ⁻³] eight hours after the event	Physical half life	$e(50)_{\text{inh}}$ [Sv.Bq ⁻¹]	Effective dose rate per unit integrated air concentration [Sv.d ⁻¹ per Bq.m ⁻³]
Xe-133	2.96×10^8	5.24 d	-----	1.20×10^{-10}
Xe-135	1.23×10^7	9.1 h	-----	9.60×10^{-10}
Xe-138	2.00×10^7	0.237 h	-----	4.70×10^{-10}
Xe-135m	6.88×10^5	0.255 d	-----	1.60×10^{-9}
Kr-87	5.37×10^5	1.27 h	-----	3.40×10^{-9}
I-131	2.73×10^5	8.04 d	1.10×10^{-8}	-----
I-133	2.90×10^5	20.8 h	2.10×10^{-9}	-----
Co-60	9.88×10^6	5.27 y	1.70×10^{-8}	-----

3 METHODOLOGY FOR INTERNAL DOSE ASSESSMENT

It was established that the worker's measurement data reported by the internal dosimetry laboratory detected in his thorax would correspond to retention data of the xenon mainly in fatty tissue, since no biokinetic model predicts that a person exposed to Xenon retains during several hours or days this gas in the lungs, but evidence that it is long retained in fatty tissue was found [6, 7, 8]. Additionally, it was observed that the measurements of internally deposited xenon were reasonably consistent with the behaviour of retained xenon in systemic tissues mainly in fat, observed in subjects and in model predictions found in literature [6, 7, 8]. Under these circumstances, it was considered that using the Xe-133 dose factors recommended by ICRP 128 for patients treated with this radionuclide by re-inhalation of the gas for 10 minutes [8] could be used for estimating Xe-133 internal dose in this scenario. Nevertheless, for applying that dose factor the intake was needed, in addition, no Xe-135 dose factor was available in that report.

While the direct dose assessment method arose as an alternative to assess the internal dose due Xe-133 and Xe-135 using the available measurement data, these measurements were not enough, since there were no data of initial lung deposition and systemic tissue uptake, which were decisive. Once again, the estimation of the intake of these radionuclides was critical, for which it was necessary to reconstruct the concentration of the gases released at the time of the event.

Consequently, ARN personnel of Radiological Protection and Physical Dosimetry areas reconstructed the exposure conditions through a concentration of $9.3 \times 10^8 \text{ Bq.m}^{-3}$ of Xe-133 and $7.3 \times 10^7 \text{ Bq.m}^{-3}$ of Xe-135. The values of the $H_p(10)$ and $H_p(0.07)$ of the EPD personal dosimeter of the worker were also used taking as reference the skin dose coefficients by immersion in the cloud from the Federal Guidance Report No.12 [9]. Knowing these concentrations, it was possible to estimate the intakes of 130.2 MBq of Xe-133 and 10.22 MBq of Xe-135, assuming a standard worker's respiration rate of $0.02 \text{ m}^3.\text{min}^{-1}$ and an exposure time of 7 minutes.

Next, two methods were proposed to assess xenon radioisotopes effective dose. The first one, applying the Xe-133 dose coefficient recommended by ICRP 128 for patients treated with this radionuclide by re-inhalation of the gas for 10 minutes [8]. The second one, implementing the direct dose assessment method. Direct dose assessment method requires calculating the area under the retention activity data, in order to determine the number of nuclear transformations in a specific organ or tissue identified as source. The committed equivalent dose deposited in the target organ is calculated as the product of the number of nuclear transformations and the dose factor in the target organ per disintegration in the source [10]. Following the biokinetic models found in literature, two main source organs were identified: lungs and fatty tissues; therefore, with the purpose of a proxy absorbed dose estimation, it was assumed that xenon not present in the lungs was distributed uniformly throughout the rest of the body. The number of nuclear transformations of rest of the body compartment was estimated using the trapezoidal method and taken into account the measured worker data. For lungs, the value of the cumulated activity for this organ recommended in ICRP 128 for the patient was assumed [8].

The direct dose assessment was implemented through the OLINDA code version 1.1 [11], which has in its database the dose factors per disintegration for various types of anthropomorphic phantoms (based on the Oak Ridge models) and radionuclides, including Xe-133 and Xe-135. In order to calculate the dose, this program requires the selection of the human model, the radionuclide of interest, and to enter the values of the time-integrated activity of the different source organs. In this way it was possible to have a proxy estimation of the doses in the different organs for both isotopes, Xe-133 and Xe-135, using an adult male phantom.

The positive results of HTO and I-131 in urine bioassays were evaluated using the biokinetic models recommended for the worker [12], under the assumption of acute inhalation and no contribution from previous intakes of these radionuclides, using the IMBA code [13].

4 RESULTS

Table 3 presents an estimation of the effective dose and the absorbed dose in different tissues. It was assumed a Xe-133 intake of 130.2 MBq (based on the modeled concentration of Xe-133 in air) and using the Xe-133 retention model recommended for patients treated with this radionuclide by rebreathing the gas for 10 minutes, and considering the dose factors recommended by ICRP 128 for this scenario [8]. $\times 10^{-1}$

Table 3: Committed absorbed dose in different tissues and committed effective dose by inhalation of 130.2 MBq of Xe-133 using the biokinetic model of the patient recommended in ICRP 128 [8].

Tissues	Committed absorbed dose (mGy)	Tissues	Committed absorbed dose (mGy)
Adrenals	1.4×10^{-1}	Muscles	1.4×10^{-1}
Bone surfaces	1.8×10^{-1}	Oesophagus	1.4×10^{-1}
Brain	1.4×10^{-1}	Ovaries	1.6×10^{-1}
Breast	1.4×10^{-1}	Pancreas	1.6×10^{-1}
Gallbladder wall	1.6×10^{-1}	Red marrow	1.4×10^{-1}
Stomach wall	1.4×10^{-1}	Skin	1.3×10^{-1}
Small intestine	1.6×10^{-1}	Spleen	1.4×10^{-1}
Colon wall	1.4×10^{-1}	Testes	1.4×10^{-1}
(Upper Large Intestine wall)	1.4×10^{-1}	Thymus	1.4×10^{-1}
(Lower Large Intestine wall)	1.6×10^{-1}	Thyroid	1.4×10^{-1}
Heart wall	1.4×10^{-1}	Urinary Bladder wall	1.4×10^{-1}
Kidneys	1.4×10^{-1}	Uterus	1.6×10^{-1}
Liver	1.4×10^{-1}	Remaining organs	1.4×10^{-1}
Lungs	1.6×10^{-1}	Effective dose (mSv)	1.4×10^{-1}

Tables 4 and 5 present the results of the committed equivalent doses in different tissues and the effective doses for Xe-133 and Xe-135 respectively, implementing the direct dose assessment, using the *in vivo* measurement data of the worker.

Table 4: Committed equivalent doses in different tissues and committed effective dose due to the intake of Xe-133 implementing the direct dose assessment, using the *in vivo* measurement data of the worker.

Tissues	Committed Equivalent Dose (mSv)	Tissues	Committed Equivalent Dose (mSv)
Adrenals	2.08×10^{-1}	Muscle	1.99×10^{-1}
Brain	2.02×10^{-1}	Ovaries	2.12×10^{-1}
Breasts	1.91×10^{-1}	Pancreas	2.12×10^{-1}
Gallbladder Wall	2.11×10^{-1}	Red Marrow	1.63×10^{-1}
LLI Wall	2.11×10^{-1}	Skin	1.87×10^{-1}
Small Intestine	2.11×10^{-1}	Spleen	2.07×10^{-1}
Stomach Wall	2.07×10^{-1}	Testes	1.98×10^{-1}
ULI Wall	2.10×10^{-1}	Thymus	2.03×10^{-1}
Heart Wall	2.07×10^{-1}	Thyroid	2.06×10^{-1}
Kidneys	2.04×10^{-1}	Urinary Bladder Wall	2.08×10^{-1}
Liver	2.07×10^{-1}	Uterus	2.12×10^{-1}
Lungs	1.68×10^{-1}	Effective dose (mSv)	1.95×10^{-1}

Table 5: Committed equivalent doses in different tissues and committed effective dose due to the intake of Xe-135 implementing the direct dose assessment, using the *in vivo* measurement data of the worker.

Tissues	Committed Equivalent Dose (mSv)	Tissues	Committed Equivalent Dose (mSv)
Adrenals	3.94×10^{-2}	Muscle	3.67×10^{-2}
Brain	3.57×10^{-2}	Ovaries	4.05×10^{-2}
Breasts	3.44×10^{-2}	Pancreas	4.03×10^{-2}
Gallbladder Wall	4.02×10^{-2}	Red Marrow	2.96×10^{-2}
LLI Wall	3.99×10^{-2}	Skin	3.37×10^{-2}
Small Intestine	4.02×10^{-2}	Spleen	3.85×10^{-2}
Stomach Wall	3.88×10^{-2}	Testes	3.67×10^{-2}
ULI Wall	3.99×10^{-2}	Thymus	3.76×10^{-2}
Heart Wall	3.88×10^{-2}	Thyroid	3.77×10^{-2}
Kidneys	3.85×10^{-2}	Urinary Bladder Wall	3.96×10^{-2}
Liver	3.85×10^{-2}	Uterus	4.07×10^{-2}
Lungs	3.24×10^{-2}	Effective dose (mSv)	3.55×10^{-2}

The effective doses by internal exposure to HTO and I-131 were estimated using the urinary excretion data showed in Table 1 fitted to their corresponding intake retention fractions and the dose coefficients for workers. The estimated committed effective doses by exposure to HTO and I-131 are equal to 7.57×10^{-2} mSv and 1.52×10^{-3} mSv respectively, under the assumption that an acute inhalation occurred and that there is no contribution from previous intakes of these radionuclides.

Table 6 presents the contribution of each radionuclide to the committed effective dose and the total committed effective dose for the two methods implemented to estimate the dose due to the intake of xenon isotopes.

Table 6: Contribution of each radionuclide to the committed effective dose and the total committed effective dose for the two implemented methods.

Radionuclide	Contribution to Committed Effective Dose (mSv) Method 1	Contribution to Committed Effective Dose (mSv) Method 2
Xe-133	1.43×10^{-1}	1.95×10^{-1}
Xe-135		3.55×10^{-2}
H-3	7.57×10^{-2}	7.57×10^{-2}
I-131	1.52×10^{-3}	1.52×10^{-3}
Total Committed Effective Dose (mSv)	2.20×10^{-1}	3.01×10^{-1}

5 CONCLUSIONS

In this work, the chronological actions to reconstruct the worker's intake and to estimate the committed effective dose, due to unexpected exposure to high concentration of gases during a maintenance task were presented. The description of the methodologies implemented to estimate the contribution to the total effective dose from the internal exposure to Xe-133, Xe-135, HTO and I-131 were also included. The assessment of internal dose by xenon isotopes was performed without biokinetic models or dose coefficients of reference for occupational intake of these isotopes.

The committed effective doses for internal exposure to Xe-133 was estimated following two methods: the first one using the dose factors recommended by ICRP for patients treated with Xe-133 (for 10 min), and the second one using the MIRD methodology and data from *in vivo* worker's Xe-133 measurement reported by the internal dosimetry laboratory. The estimated effective dose for exposure to Xe-133 using method 2 was very similar to that estimated using method 1, therefore it could be concluded that the results of positive chest measurements, reported by the internal dosimetry laboratory, were consistent with retention of xenon in fatty tissue.

Since the contribution to the dose from exposure to Xe-135 cannot be obtained by applying method 1, it was recommended that the total committed effective dose value assigned to this event, taking into account all the measured radionuclides, be considered 0.3 mSv.

Finally, although the dose estimated was much lower than the dose limits and dose restrictions for workers, the causes that gave rise to the event are being analyzed.

6 ACKNOWLEDGMENTS

The authors wish to thank Dr. James Marsh for the paper provided and his valuable comments.

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Training Activities Carried out by Intervention in Radiological and Nuclear Emergencies Department (SIERyN) of the Nuclear Regulatory Authority (ARN) of Argentina in Times of COVID-19

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Training activities carried out by Intervention in Radiological and Nuclear Emergencies Department (SIERYN) of the Nuclear Regulatory Authority (ARN) of Argentina in times of COVID-19.

Autoridad Regulatoria Nuclear – Buenos Aires - ARGENTINA

INTRODUCTION

As a result of the global COVID pandemic, SIERYN had to create new ways to conduct its training virtually, establishing strategies and methodologies related to educational training programs for radiological and nuclear emergency scenarios.

The first step was to train the ARN staff involved in the task. Later, all the material used in the face-to-face presentations was adapted to the virtual format. For this, more dynamic, attractive and modern tools were used to strengthen knowledges in response to emergencies through software such as Genially, Powtoon, Articulate-Rise into LANENT Educative Platform (<https://www.lanentweb.org/es>).



Platform LANENT allowed all the information to be concentrated in a single site, acting as a virtual classroom. It let improve that participants gain new skills having access all time classes that included activities like practical activities and videos. Synchronous classes were carried out through a virtual platform with working groups, using polls; practical and dynamic activities (card game, desk exercise, videos with discussions).



During 2020 and 2021, several workshops were held based on the IAEA First Responders Manual in virtual format for first responders in radiological emergencies. With topics such as: concept of operations, risks and effects of ionizing radiation on health, risk assessment and establishment of safety perimeter, safety work guidelines for emergency personnel. The workshops were aimed at personnel from response organizations such as: Police, Civil Defense, Firefighters from all over the country.

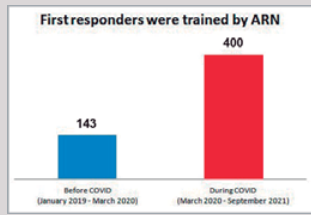
Also, Protection measures for a nuclear emergency were also disseminated at the educational community of the towns located to 10 km around Embalse Nuclear Power Plant - Cordoba Province, Argentina - training more than 300 teachers of all educational level.

POSSITIVE POINTS

- The first aid workshop has been offered to first responders across the country; being more equitable because resources or distance to Buenos Aires (where ARN is located) were not an obstacle.
- A face-to-face course has a maximum capacity of 40 people; while the virtual one was carried out with 100 attendees, offering the opportunity to reach a large number of participants.



Geographical location of the participants of the Radiological Emergency Response First Responders Course (during COVID) – done by ArcGis Survey.



More than 400 first responders and more than 300 teachers were trained.

CONCLUSIONS

- We identify those virtual methods don't have the same impact as a face-to-face course, because there were fewer moments for consultation and discussion. In addition, the quality of sound and/or image is depending of different problems of local connection via internet.
- This virtual adaptation for training people has allowed comply the institutional commitment training to first responders in case of radiological emergencies and school community around 10 km from the Embalse Nuclear Power Plant in case of a nuclear emergency.
- The result obtained after the used of virtual methodology was very satisfactory, offering a sustainable virtual infrastructure and capabilities for training.

Protection against Ionizing Radiation *vis-à-vis*. Protection against Non-Ionizing Radiation: Different Approaches

Touzet, R. and González, A.J.

Protection against ionizing radiation *vis-à-vis* Protection against non-ionizing radiation: Different approaches

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Abstract: The purpose of this paper is to explore an apparent dichotomy between the protection against ionizing radiation (IR) and the protection against non-ionizing radiation (NIR). The international and intergovernmental radiation safety system for IR is: universal and consensual; founded on internationally accepted science accorded at the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR); based on a universally accepted paradigm developed over the years by the International Commission on Radiological Protection (ICRP); resulted in an intergovernmental regime of standards co-sponsored by all relevant international agencies under the aegis of the International Atomic Energy Agency (IAEA); enforced by obligations undertaken by States; and, including provisions for practical applications supported by all relevant international agencies. For the protection against NIR, the *proxy* is the International Commission on Non-Ionizing Radiation Protection (ICNIRP), created by IRPA on 1992. After 30 years its work is not replacing the combined effort of UNSCEAR, ICRP and the intergovernmental agencies. Such differences in protection approaches between IR and NIR are against the fundamental bases of IRPA. The interest of IRPA, its constituting societies and their thousand professional members, is to resolve the gap. They need clear answers to such basic questions as: What is the internationally endorsed consensual science on NIR? What is the ethical basis of the protection paradigm and the factual protection principles being used for NIR? What is the intergovernmental regime of safety standards and obligations for NIR? What are the provisions for the global application of such standards? The paper concludes that the time seems to be ripe for closing the gap between protection against IR and protection against NIR.

KEYWORDS: *Ionizing radiation; Non-ionizing radiation; Radiation protection; ICNIRP.*

1. INTRODUCTION

Most radiation protection professionals grouped in national radio-protection societies and these societies, which – duly associated – have constituted the International Radiation Protection Association (IRPA), seems to be convinced on the benefit of an international and intergovernmental radiation safety system. Such a system should: be universal and consensual; be founded on international science; be based on a universally respected paradigm; result in an intergovernmental regime of standards and binding obligations; and, include provisions for practical applications supported by international professional societies. The protection against ionizing radiation (IR) can proudly show such a system. Unfortunately, this is not the case for the protection against non-ionizing radiation (NIR).

The purpose of this paper is to explore such dichotomy. For reasons discussed in the paper, the differences in protection approaches between IR and NIR are against the fundamental roots of IRPA. It is in the interest of IRPA, its constituting societies and the thousand professionals forming IRPA, to resolve the gap.

2. THE IR PROTECTION SYSTEM

The IR protection system has a long tradition. After more than a century of professional activities a global safety system for IR has been consolidated, becoming one of the more significant international and intergovernmental successes

The international and intergovernmental radiation safety system for IR is universal and consensual and founded on an extended international and intergovernmental accord, as follows:

- it is founded on internationally accepted science accorded at the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and endorsed by the highest international intergovernmental body, the United Nations General assembly (UNGA);
- it is based on the universally accepted paradigm developed over the years by the International Commission on Radiological Protection (ICRP);
- it has resulted in an intergovernmental regime of standards, which under the aegis of the International Atomic Energy Agency (IAEA), is co-sponsored by all relevant international agencies, the European Atomic Energy Community (Euratom), the Food and Agriculture Organization of the United Nations (FAO), the International Labour Organization (ILO), the International Maritime Organization (IMO), the OECD Nuclear Energy Agency (OECD/NEA), the Pan American Health Organization (PAHO), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO);
- its is generally enforced by obligations undertaken by States, such as the 1960 ILO Radiation Protection Convention No. 115, and the many Conventions and Codes of Conduct agreed under the aegis of the IAEA; and,
- it includes provisions for practical applications supported by all relevant international organizations, including IRPA.

3. THE NIR PROTECTION SYSTEM

For NIR, a comparable system to the IR system does not exist.

The *proxy* is the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and some activities carried out by the WHO.

The ICNIRP was created by IRPA on May, 1992, in Montreal, to continue the work previously conducted by the IRPA's International Non-Ionizing Radiation Committee. Its *leitmotiv* was 'advancing NIR protection for the benefit of people and the environment'.

In theory, at least, IRPA and ICNIRP should have had a strong relationship, e.g., much powerful that the liaison between IRPA and the relevant IR organizations such as UNSCEAR, ICRP or the IAEA. By statutory mandate ICNIRP shall submit its formal recommendations on protection against NIR for comment by the IRPA Executive Council and the IRPA Associate Societies, prior to publication. Moreover, IRPA shall contribute an annual grant for ICNIRP. Thus, while ICNIRP was created as an independent body, from a scientific point of view, its statutory mandate call it for an strong association to IRPA.

4. DIFFERENT APPROACHES

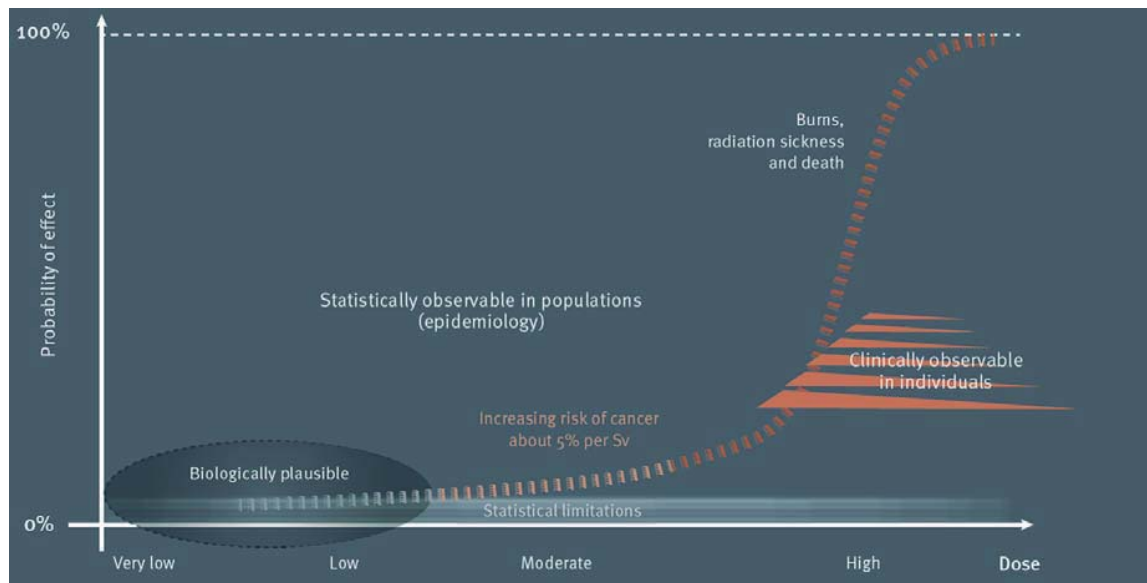
4.1. Consensual Science

4.1.1. IR

The consensual scientific bases for protection against IR are provided by UNSCEAR. This unique organization was established by UNGA in 1955. While its name refer to 'atomic radiation' (i.e., given the impression that it could deal with both IR and NIR, its mandate however was limited to assess and report levels and effects of exposure to IR [1]. Governments and organizations

throughout the world rely on the UNSCEAR's estimates as the scientific basis for establishing protective measures against IR.

UNSCEAR has, relatively recently, provided estimates on the attribution to IR of effects on health *vis-à-vis* the inference of IR risks. [2] UNGA has unanimously welcomed with appreciation the scientific report of UNSCEAR on this issue [3]. The UNSCEAR estimates have been summarized by UNEP [4], and condensed in a simplified IR's exposure-response relationship, which is presented in Figure 1.



↑
**PROTECTION
 PRINCIPLES
 BEING APPLIED
 HERE**

Figure 1: Simplified IR's exposure-response relationship

The Simplified IR's exposure-response relationship in Figure 1 present three zones clearly differentiated, as follows:

- levels of exposure at which effects are *clinically observable in individuals*;
- levels of exposure at which effects are *epidemiologically observable in populations*; and,
- levels of exposure where the effects are just *biologically plausible* (marked an ovals in the figure).

It is important to underline this differentiation. As indicated in Figure 1, the protection policy against IR would be based on protecting people being exposed to incur effects that are considered biologically plausible but not observable.

4.1.2. NIR

There is not a similar process for achieving international scientific consensus on the effects of NIR. There is no a similar international intergovernmental organization like UNSCEAR achieving such a needed consensus at the highest governmental level. The ICNIRP appears to be acting as a *proxy* for this process

The achievement of internationally recognized consensual science seems to be difficult to achieve. Just as an example, there have been divergences between ICNRP and other relevant institutions on the crucial issue of the biological plausibility of carcinogenic effects following NIR exposure.

For instance, the US National Toxicology Program (NTP) concluded that long-term exposure to radiofrequency (RF) electromagnetic fields (EMFs) associated with mobile (or cell) phones or base stations appears to be carcinogenic. The NPT provides the scientific basis for U.S.A. programs, activities, and policies that promote health or lead to the prevention of disease. Founded in 1978, NTP plays a critical role in generating, interpreting, and sharing information about potentially hazardous elements and strives to remain at the cutting edge of scientific research and the development and application of new technologies. NPT has being involved in a large number of studies of NIR carcinogenesis

Similar conclusions on NIR carcinogenic were reported by the prestigious Ramazzini Institute in Italy. The Ramazzini institute is a prestigious non-profit social cooperative that has dedicated more than two decades to fighting cancer. Its activities focus on three areas of action: scientific research, early diagnosis, and spreading information. The Institute collaborates with the Collegium Ramazzini, an international academy with about 180 fellows in 32 countries.

However, the ICNIRP concluded that substantial limitations in their studies preclude conclusions being drawn concerning RF and EMFs and carcinogenesis [5].

Many other prominent institutions have been investigating the carcinogenic plausibility of IR. They include the prestigious International Agency for Research on Cancer (IARC), an intergovernmental agency forming part of WHO, whose role is to conduct and coordinate research into the causes of cancer [6].

The bibliography on plausibility of carcinogenic effects of NIR is vast. For instance, a substantive compilation can be found at the WHO's Environmental Health Criteria documents that provide international, critical reviews on the effects of *inter alia* NIR on human health and the environment.

Notwithstanding the vast availability of information discussing the biological plausibility for NIR exposure to be carcinogenic, it seems that there is not yet full consensus for attributing unequivocally detrimental health effects to NIR exposure. This will require larger and well designed epidemiological studies of human populations, in addition to those available. But the evidence seems to be overwhelming towards a consensus on the *biologically plausibility* that NIR exposure might be carcinogenic. Such a consensus however is not available. There is not an international institution similar to UNSCEAR building up such a consensus.

In sum, it seems that there is not an international mechanism available to reach a universal scientific consensus on the detrimental health effects of NIR exposure. A basic question remains without answer: **How to build a universally accepted protection paradigm for NIR if there is not an international consensual science to support it?**

4.2. Universal paradigm

4.2.1. IR

The universal paradigm governing the protection against IR has been recommended by the ICRP and used worldwide. The ICRP is a charity (not-for-profit organisation) registered with the Charity Commission of England and Wales, which was established in 1928 at the second International Congress of Radiology to respond to growing concerns about the effects of IR being observed in the medical community. The ICRP presents itself as ‘an independent, international organisation that advances for the public benefit the science of radiological protection, in particular by providing recommendations and guidance on all aspects of protection against ionising radiation’. The ICRP paradigm has been built over the years on the basis a solid ethic doctrines and consequential core values, resulting in the latest ICRP recommendations [7].

The basic ethical doctrines giving basis to the ICRP paradigm have been discussed elsewhere [8]. They comprehend individual oriented ethical doctrines and societal oriented ethical doctrines. The individual oriented ethics include the deontological ethics, based on duty, responsibility and obligation (*not do unto others what they should not do unto you*), and the areté (ἀρετή) ethics, based on virtue and asset (*do good to others even if it will not be returned*). The societal oriented ethics include the teleological ethics, based on consequence, result, and outcome (*mind the ends, which justify the means*) and the utilitarian ethics, based on utility, helpfulness and effectiveness (*do the greatest good for the greatest number of people*). A proper balance of these somehow disparate ethical doctrines has been used to formulate the principles of the IR protection paradigm.

The ethical foundations of the IR paradigm has resulted in the core values of the IR protection system. These have been reported by ICRP [9] and include the following:

- beneficence and non-maleficence, which prevents harmful effects for humans and the environment;
- prudence, which allows uncertainties to be taken into account;
- justice, which ensure social equity and fairness in decisions; and,
- dignity, which consider the respect that one must have for people.

On these bases the basic principles of the paradigm for the protection against IR has been built [7]. They comprehend, as it is well know by the radiation protection community, the *justification* of decisions involving changes in the exposure to IR, the *optimization* of options of the protection against IR; and the *limitations* (or restrictions) of individual exposures. An embedded principle in the ICRP principles is the protection of future generations and the environment; notwithstanding, the safety fundamentals of the international intergovernmental organizations recognize it as a separate principle. A further classification of the ICRP paradigm includes the situations given rise to IR exposure, extant, planned and emergency, and the type of exposures, occupational, public, and medical

4.2.2. NIR

The main function intended by IRPA for ICNIRP seems to have been to recommend a protection paradigm for the protection against NIR, following, *mutatis mutandi*, that paradigm build over the years by ICRP for the protection against IR. It has not been clear, however, on what ethical basis the NIR protection paradigm would be built. As a result, it is not clear what the radiation protection principles of this paradigm should be.

After a lot of questioning in this regard, just recently, nearly six lustrum after its constitution, the ICNIRP issued an 'ICNIRP statement on principles for non-ionizing radiation protection'[10]. In these principles is stated declared that the general principles for NIR protection are based....upon the well-established principles in ICRP 2007 and the under-pinning ethical values published by ICRP. This declaration is very much welcomed, because for the first time in many years a clear framework of principles was declared for the protection against NIR.

Notwithstanding this welcomed declaration, it is not clear how it will be properly implemented in practice. For instance,

- For the justification principle both ICRP & ICNIRP states that any decision that alters the radiation exposure situation should do more good than harm'. However, there is an ICNIRP proviso: ICNIRP indicates that it does not explicitly address social and economic issues, as these are deemed to be the remit of governments and relevant authorities (?!). It is not clear how the justification principle could be addressed without addressing social and economical issues.
- For the optimization principle, while the ICRP: aims at the best protection under prevailing circumstances, the ICNIRP declares that: when the exposure restrictions set by ICNIRP are well below threshold levels for adverse health effects [?], further reduction in the limit values does not result in additional health benefits, and therefore ...optimization is not necessary [!].
- For the limitation principle, while the ICRP recommends limits of individual exposure for restricting inferred risks for stochastic effects, namely effects that are biologically plausible but not necessarily attributable, and which are well below the thresholds for deterministic effects and the epidemiological limits for detecting increases in the incidence of stochastic effects, the ICNIRP: declares that exposure is limited to either below the level with an accepted risk for adverse effects, or below the threshold level for adverse health effects, where it is feasible to reduce the exposure to below these thresholds
- For the principle of future and the environment, which is implicitly recognized by ICRP and established in international safety fundamentals (see hereinafter), while ICRP recommends to limit the exposure committed rather than the exposure incurred, and that the environment be protected for maintaining biological diversity, ensuring the conservation of species, and protecting the health and status of natural habitats, communities, and ecosystems, it is absolutely unclear what the position of ICNIRP is on this crucial issues.

It seems that there is a mismatch between the ICRP paradigm intentions and the ICNIRP understanding. .

Intergovernmental regime

4.3.1. IR

A very comprehensive intergovernmental safety regime on the safety of activities involving the exposure to IR has been built by the system of intergovernmental international organizations over a period of more than half a century. It was triggered by resolutions of the policy making organs of the IAEA [11]

It is sustained on Fundamentals Safety Principles [12] including: responsibility for safety; role of government; leadership and management for safety; justification of actions; optimization of protection; limitation of risks to individuals; protection of present and future generations prevention of accidents; emergency preparedness and response; and, protective actions to reduce existing or unregulated radiation risks.

In addition to the Safety Fundamentals, which present the fundamental safety objective and principles of protection and safety in relation to IR, the system includes a plethora of Safety Requirements and Safety Guides.

The Safety Requirements are an integrated and consistent set of regulatory documents that establish what must be met to ensure the protection of people and the environment against IR, both now and in the future. The *primus inter pares* requirement for protection against IR is the so-called Basic Safety Standards [13]. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of these international requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered ‘overarching’ requirements, are expressed as ‘shall’ statements.

The Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The guidance provided in Safety Guides are expressed as ‘should’ statements.

The corpus of safety fundamentals, requirements and guides comprehend hundreds of documents establishing precise safety standards for the protection against IR.

4.3.2. NIR

Nothing equivalent or even similar to the international intergovernmental safety regime for IR exist for NIR. The establishment of an international and intergovernmental safety regime of standards and obligations for the protection against NIR is beyond the statutory competence of ICNIRP.

4.3. Provisions for practical applications

4.4.1. IR

A system exists for providing for the application of the standards and guides established by the international intergovernmental safety regime. it include *inter alia*:

- providing technical assistance to requesting States;
- fostering information exchange among specialists;
- promoting education & training for the new professionals;
- coordinating research & development among specialised centres and laboratories; and, last but not least,
- rendering appraisal services for checking compliance with standards

4.4.2. NIR

For NIR there is nothing equivalent or even similar than the system of provisions for the application of the standards for IR. However, ICNIRP has had some initiatives in this regard. Workshops organized by the ICNIRP, such as the International NIR Workshop that was planned in the framework of IRPA15 and had to be cancelled, are examples of attempts to foster information exchange.

5. CONCLUSIONS

IR and NIR are within the remit of IRPA. The system of protection against IR precedes IRPA. Being conscious of the challenges of NIR, IRPA duly created an International Non-Ionizing Radiation Committee and then, in 1992, ICNIRP. IRPA itself and its constituencies were supposed to be duly informed by ICNIRP on the evolution of the protection system for NIR.

Notwithstanding these good intentions, 30 years after, a number of fundamental questions remain and merit unambiguous answers. What is the international consensual science on the detrimental health effects of exposure to NIR? What is the rational ethics of the paradigm of protection against NIR and what are its real protection principles being used for NIR? What is the intergovernmental system of standards and obligations that are planned in order to formalize internationally the protection against NIR? What provisions are settled for the practical applications of protection standards against NIR?

The years are passing and many colleagues might be questioning whether we are treating the protection against NIR with the same ethical considerations that we have treated the protection of IR. It seems to be essential for the national radiation protection societies constituting IRPA and their plethora of radiation protection professionals, as well for IRPA itself, to search for unequivocal and unambiguous answers to the questions raised heretofore. The time seems to be ripe for closing the gape between protection against IR and protection against NIR!

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INES, much more than a Methodological Scale to Inform Safety Significance of an Event

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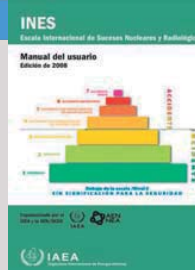


INES, much more than a methodological scale to inform safety significance of an event.

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INTRODUCTION

The International Nuclear and Radiological Event Scale (INES), was created in 1990 as a communication tool with the aim to facilitate the understanding of the safety significance and the associated risk of nuclear and radiological events among the general public. The technical information considered in INES's rating methodology can facilitate the inclusion of new approaches, developing and implementing different mechanisms and strategies to strengthen capacity building in regulatory bodies to avoid the occurrence of radiological and nuclear events, acting in the public interest, in order to promote confidence and trust. Nevertheless, the evaluation of international information concerning the occurrence of radiological and nuclear events, informed voluntarily by Member States (MS) applying INES, show that similar radiological events keep occurring, up to now. This is the reason why the safety significance must be evaluated to change of vision of regulatory bodies, including the impact of this information in different aspects such as: regulatory infrastructure, new and more deep regulations, evaluation of some repetitive events in order to establish procedures to prevent similar situations, etc. Other aspect is the impact of this information in members of the public about risk and the role of regulatory body. The inclusion of this initiative will offer a change in the concept regarding the use of lessons learned and experience gained.



METHODOLOGY

One of the relevant issues of this evaluation is that, despite the development of more and better tools for regulatory control and supervision during the use of radioactive material, radiological incidents continue to be reported by Member States. INES, as a communication tool, is an element that provide information about the radiological events that have occurred but, what other mechanisms can be initiated with this information?. This is a brief description of some elements that should be analyzed within the regulatory structure every time that an event is reported voluntarily by a Member State.

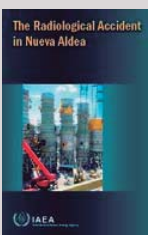
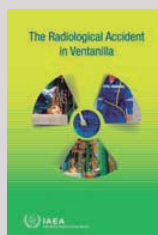
THE MEMORY EFFECT

- There are many examples that will remain in our memory when we evaluate the radiological accidents of the past.
- We will continue to talk about lessons learned and improvements, but there is certainly still work to be done.

LESSONS
LEARNED

AGAINST

LESSONS NOT
LEARNED



Examples of radiological accidents with overexposure to radiation in industrial radiography.

Questions about Infrastructure and Standards	Logical Answers
Is the information about an event reported by MS relevant for regulatory body (RB) or competent authority (CA)?	YES
Is the information reported by MS relevant to check the methodology used to perform audit or inspections for RB or CA?	YES
Is the information reported by MS relevant to introduce changes in the structure of RB or CA?	YES
Is the information reported by MS relevant to introduce changes in national standards or law for RB or CA?	YES
Is the information reported by MS relevant to discuss into the RB or CA in order to detect mistakes or weaknesses?	YES
Questions about Training and Education Courses	Logical Answers
Is the information reported by MS relevant to be included into the structure of training courses for users of radioactive and nuclear materials?	YES
Is the information reported by MS relevant to be included into the structure of training courses of personnel with regulatory functions?	YES
Is the information reported by MS relevant to be included in workshops or seminars or meetings to discuss about lessons learned and experience gained?	YES
Questions about Nuclear and Radiological Emergency Response	Logical Answers
Is the information reported by MS relevant to introduce changes in the methodology to respond to a radiological or nuclear emergency?	YES
Is the information reported by MS relevant for other institutions to learn more about emergency response?	YES
Is the information reported by MS relevant to other organizations in the country? (civil defense, police, firemen, etc.)	YES
Last Question	Logical Answer
Is the information reported by MS relevant to prepare a new strategy or initiative to avoid new radiological and nuclear events?	YES

FINAL REMARKS

This information on radiological incidents and accidents proposes an evaluation of the event, in order to avoid similar situations of radiological risk as well as for opportunities for improvement both in the regulatory area and in the tasks of authorized users of radioactive material

- ✓ Not to compare countries
- ✓ Not to compare results or consequences of events
- ✓ Not to compare regulators or regulations
- ✓ Not to compare users of radioactive and nuclear materials
- ✓ Not to compare standards or laws
- ✓ Not to compare....

CONCLUSIONS

- An opportunity for improvement would be the use of the information provided regarding events notified by MS that apply the INES, as a tool that allows the evolution of the regulatory system.
- In this sense, the mechanisms and methodologies used for regulatory control should be increased, introducing the experience gathered from these events as an opportunity for improvement.
- This would allow the detection of errors and weaknesses in the regulatory system, in order to provide the means to lessen the probability of new radiological or nuclear incidents, while increasing capacity building and its commitment to safety.

Probabilistic Approach for Nuclear Safety Regulation in Argentina

Campos, J.M. e Ibarra, V.

Presentado en: Technical Meeting on Experience in the Development and
Application of Level 2 PSA for NPP.
Viena, Austria, 4 al 7 de mayo de 2021

Probabilistic approach for nuclear safety regulation in Argentina

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ABSTRACT

Probabilistic safety assessment is currently a widely used tool for nuclear safety analysis. However, one of its main obstacles is the difficulty, due to the recognized uncertainties, to set specific quantitative criteria for safety. Whereas many licensing authorities have adopted criteria in the form of *targets, goals or reference values*, Argentine Nuclear Regulatory Authority (ARN) has a clear acceptability criterion for potential exposure risks based on the probabilistic concept of individual radiological risk, which is compatible with ICRP's dose limitation system philosophy used for radiation protection purposes.

The aim is to limit the individual risk related to potential exposures to values analogous to the individual risk associated with exposures arising from normal operation.

The safety level of a certain facility is assessed by ARN through the regulatory tool called "Acceptability Criterion Curve" (Figure 1), which is an iso-risk curve of 10^{-7} for doses higher than 0,2 mSv.

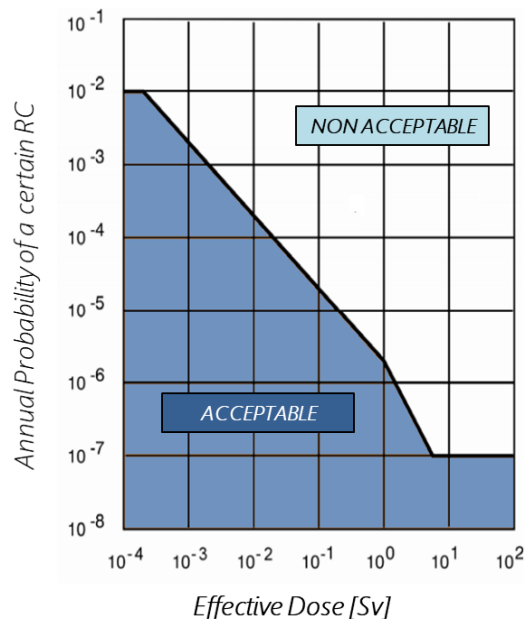


Figure 1. Acceptability Criterion Curve

This licensing criterion is focused on the design, so the fulfillment of the Acceptability Criterion Curve must be assessed before the facility construction stage or if any major design changes are to be made on an operating facility.

The Acceptability Criterion Curve is not only a licensing tool, but also a way to identify design improvements to effectively reduce the overall risk of a certain design and to compare, from the risk point of view, different designs and concepts.

The commissioning of the Atucha II NPP was the first project in which this regulatory tool was fully requested, and it was fulfilled by means of a Level 3 PSA. As for the PSA Level 2, representative severe

accident sequences were analyzed by MELCOR code whilst accident progression event trees have been evaluated by EVNTREE code. A Severe Accident Management Program was elaborated on this basis, which also provided insights for developing the SAMP for the Atucha I NPP.

In the case of the SMR CAREM-25, a design-stage PSA was performed to assess fulfillment of the Acceptability Criterion Curve, which demonstrated a very low risk associated with this design.



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Probabilistic approach for nuclear safety regulation in Argentina

Juan Martín CAMPOS – Víctor IBARRA

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Probabilistic approach for nuclear safety regulation in Argentina

Outline

- Acceptable Risk Limit
- Acceptability Criterion Curve
- Licensing Requirements
- Licensing Criterion
- Cases

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Probabilistic approach for nuclear safety regulation in Argentina

Acceptable Risk Limit (1/2)

Argentine Nuclear Regulatory Authority (ARN) acceptability criterion for potential exposure risks is based on the probabilistic concept of individual radiological risk. This concept is compatible with ICRP's dose limitation system philosophy used for radiation protection purposes.

In this context, the individual risk is defined as the probability that an individual is exposed to ionizing radiation as a result of an accident and then dies due to that exposure:

$$R_i = P_{exp} \cdot P_{\left(\frac{D}{exp}\right)} = P_{exp} \cdot 0,05 \text{ Sv}^{-1} \cdot E \quad [\text{Eq. 1}]$$

The total individual risk is obtained by summing the risks associated with exposures from all credible accidental sequences (or group of sequences):

$$R_T = \sum_N R_i \quad [\text{Eq. 2}]$$

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Probabilistic approach for nuclear safety regulation in Argentina

Acceptable Risk Limit (2/2)

The aim is to limit the individual risk related to potential exposures to values analogous to the individual risk associated with exposures arising from normal operation.

The value of this limit is obtained by affecting ARN's dose constraint to exposures from a single source with ICRP's risk coefficient for stochastic effects:

$$R_T = 0,3 \text{ mSv} \cdot 0,05 \text{ Sv}^{-1} = 1,5 \cdot 10^{-5}$$

Additionally, to account for uncertainties inherent to probabilistic techniques, such as PSA, the acceptable risk limit is decreased by a factor of 15:

$$\text{Acceptable Risk Limit } (R_T) < 10^{-6}$$

This means that the total risk of death from all potential exposure scenarios for any individual of the public must be lower than 10^{-6} .



Probabilistic approach for nuclear safety regulation in Argentina

Acceptability Criterion Curve (1/3)

The safety level of a certain facility is assessed by ARN through the regulatory tool called "Acceptability Criterion Curve".

Considering the annual probability of any accidental sequence (or group of sequences) (P_{exp}) and the effective dose resulting from that accidental sequence (or group of sequences) (E) as variables, this curve is obtained by plotting $P_{exp} = f(E)$.

The treatment of the full set of accident sequences, and their corresponding source terms, is simplified by grouping them into release categories (RC). For each RC a representative accidental sequence is selected, taking the one with the worst radiological consequences. Besides, the annual probability assigned to a given RC is the sum of the annual probabilities of the accident sequences that constitute that RC.

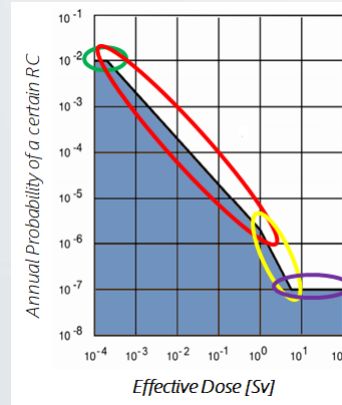
If it is assumed that with $N=10$ Release Categories all the accidents can be included, the contribution to the risk of each of those RC must be $< 10^{-7}$.



Probabilistic approach for nuclear safety regulation in Argentina
Acceptability Criterion Curve (2/3)

Taking into account that the probability of dying due to a certain exposure is a function of the effective dose (E) incurred, different sections can be identified in the Acceptability Criterion Curve:

- The stochastic effects section, for doses lower than 1 Sv (Slope = 0,05 Sv⁻¹).
- The hypothesis of certainty of death for doses higher than 6 Sv.
- The section between 1 and 6 Sv is a linear interpolation between the two previous sections (conservative approximation of the sigmoid section of the dose-response curve characteristic of this dose range).
- The section for doses lower than 0,2 mSv depicts the ARN criterion of considering non-acceptable any RC with a high probability of occurrence.



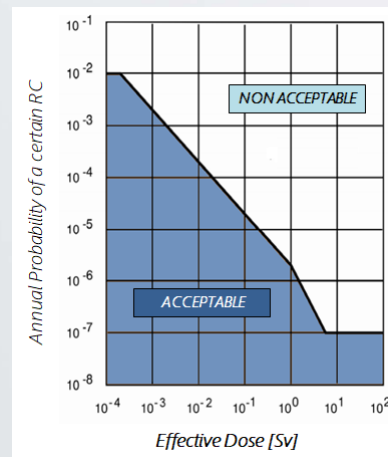
Probabilistic approach for nuclear safety regulation in Argentina
Acceptability Criterion Curve (3/3)

The Acceptability Criterion Curve is an iso-risk curve of 10⁻⁷ for doses higher than 0,2 mSv.

The curve defines two zones:

- The Acceptable Zone, where each point has a risk value lower than 10⁻⁷.
- The Non-acceptable Zone, where each point has a risk value higher than 10⁻⁷.

For the full set of accidental sequences with radiological consequences for the public the annual probability occurrence for each one of them shall be that, when represented according to the corresponding effective dose, results in a point located in the acceptable area.



Probabilistic approach for nuclear safety regulation in Argentina

Licensing Requirements

For Nuclear Power Plants, Standard AR 3.1.3 (first version published in 1979) states that:

- *All the accidental sequences with radiological consequences for the public must be identified.*
- *Annual probability of occurrence of each sequence must be calculated by means of failure trees and event trees (e.g. Level 1 and Level 2 PSA).*
- *Effective dose to the representative person must be calculated, taking into account meteorological conditions and their probabilities of occurrence This implies:*
 - *For each sequence, a fully characterized source term and its frequency must be obtained (e.g. Level 2 PSA).*
 - *An atmospheric dispersion model and a dosimetric model must be employed over each source term (e.g. Level 3 PSA)*
- *Application of countermeasures shall not be accounted*

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Probabilistic approach for nuclear safety regulation in Argentina

Licensing Criterion

This licensing criterion is focused on the design, so the fulfillment of the Acceptability Criterion Curve must be assessed before the facility construction stage or if any major design changes are to be made on an operating facility.

If any accidental sequence fall into the "Non Acceptable" region, the design must be adjusted by introducing modifications that may either reduce the likelihood of the sequence (e.g. improving safety system features), or reduce its consequences (e.g. adding or improving mitigation systems).

Even if all the accidental sequences fall into the "Acceptable" region, this methodology allows to rank, from the risk point of view, the full set of accidental sequences, which can become an important decision-making tool to improve the overall safety of the facility.

The Acceptability Criterion Curve is not only a licensing tool, but also a way to identify design improvements to effectively reduce the overall risk of a certain design and to compare, from the risk point of view, different designs and concepts.

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Probabilistic approach for nuclear safety regulation in Argentina

Cases (1/6)

Atucha II NPP

- *The original project started in 1982. The construction was suspended in 1994. In 2006 the project was restarted. Commercial operation started in 2016. Acceptability Criterion Curve was fulfilled by means of a Level 3 PSA.*
- *Level 2 PSA*
 - *Representative severe accident sequences analyzed by MELCOR integral code and accident progression event trees evaluated by EVNTREE code.*
 - *No credit given to severe accident management measures.*
 - *Key results:*
 - *Analysis of RPV failure after core melt down.*
 - *Analysis of corium behavior after reaching the cavity.*
 - *Containment failure modes*
 - *Evaluation of dominant RC.*

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Cases (2/6)

- *On the basis of the Level 2 PSA, a Severe Accident Management Program was developed.*
- *In the light of the Fukushima Daiichi Accident, a stress test, similar in content to the one that WENRA implemented, yielded as a result that there were no relevant weaknesses that require urgent actions, but, for the purposes of increasing the capacity to respond to extreme situations, an assessment of feasibility for an external RPV cooling strategy was required.*
- *The study, which finished in 2019, concluded that an external RPV cooling strategy was neither feasible, nor effective.*
- *Splitting the corresponding RC into its constituent accidental sequences, early release sequences were identified.*

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Probabilistic approach for nuclear safety regulation in Argentina *Cases (3/6)*

Atucha I NPP

- *Started operating in 1974, so fulfillment of the Acceptability Criterion Curve assessment was not applicable.*
- *Level 1 ½ PSA (Source term assessment not included)*
- *Severe Accident Management Program developed by extrapolating insights from Atucha II Level 2 PSA.*
- *Safety analysis is performed as part of a Periodic Safety Review (SSG-25).*
- *The possibility of a Long Term Operation is being evaluated.*

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Probabilistic approach for nuclear safety regulation in Argentina *Cases (4/6)*

Embalse NPP

- *Started operating in 1983, so fulfillment of the Acceptability Criterion Curve assessment was no applicable.*
- *Refurbishment Project started in 2007 and completed in 2018. Second operating cycle started in 2019.*
- **Level 2 PSA**
 - *Representative severe accident sequences analyzed by MAAP4-CANDU integral code and accident progression event trees evaluated by RiskSpectrum code.*
 - *Acceptance criterion was taken from document INSAG-12 "Basic Safety Principles for Nuclear Power Plants": The objective for large off-site releases requiring short term off-site response shall be 10^{-5} events per reactor-year.*
 - *Characterization of the source terms was out of the scope of this study.*

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Cases (5/6)

Embalse NPP

- *Design improvements to deal with Severe Accidents taking into account Level 2 PSA insights:*
 - *Addition of line to add water in the Calandria Vault from outside the reactor building.*
 - *Addition of a rupture disk to the Calandria Vault in order to increase release capacity, in case the moderator is lost as a heat sink.*
 - *Addition of autocatalytic hydrogen recombiners in the Reactor Building.*
- *Severe Accident Management Program*
 - *Based on the Generic Guidelines elaborated by CANDU Owner's Group*
 - *After the Specific Guidelines were developed, some revisions were carried based on the insights of Level 2 PSA:*
 - *SAG-3 "Control Calandria Vault Conditions"*
 - *SAG-6 "Control Containment Conditions"*

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Probabilistic approach for nuclear safety regulation in Argentina

Cases (6/6)

CAREM-25

- *A design-stage PSA was performed to assess fulfillment of the Acceptability Criterion Curve.*
- *A very low risk associated with the design was demonstrated.*
- *Final design is expected to have risk values even lower.*
- *CNEA (designer and constructor) will give a presentation on this topic.*

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Application of the NaIGEM Code for Uranium Enrichment Measurements by Gamma Ray Spectrometry with Lanthanum Bromide Detectors

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Non-Destructive Assay Techniques for Nuclear Safeguards.
Viena, Austria, 16 al 18 de febrero de 2021

Application of the NaIGEM Code for Uranium Enrichment Measurements by Gamma-ray Spectrometry with Lanthanum Bromide Detectors

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ABSTRACT

The NaIGEM code (Nuclear Instruments and Methods A 458 (2001) 196) has been initially developed to non-destructively determine uranium enrichment by analyzing low energy resolution gamma-ray spectra collected with sodium iodine (NaI) detectors based on a fitting procedure that is capable of obtaining the intensity of the 186 keV gamma-ray from ²³⁵U with better accuracy and precision than the original “enrichment meter principle” (Progress report LA-4605-MS, Los Alamos National Laboratory, NNM, 1970, p. 19), which uses two regions of interest, one for the referred peak and another for the background. With the advent and commercial availability of lanthanum bromide (LaBr₃) detectors, a type of scintillation crystal that provides better energy resolution, relative efficiency and temperature stability than the NaI crystal, upgraded versions of the NaIGEM code have been developed to include the capability of analyzing gamma-ray spectra collected with LaBr₃ detectors. Since then, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) extensively uses this medium resolution NDA system to perform uranium enrichment measurements in the field during safeguards inspections conducted in Argentine and Brazilian nuclear facilities. At the domestic level, representatives of the State Authorities of Brazil and Argentina also use the system as a tool to verify operator’s declared data. The experience on using the NaIGEM code and LaBr₃ detectors to perform uranium enrichment measurements in Argentina and Brazil over the last years is discussed and performance values are presented. The main types of measured items include natural and low enriched UF₆ cylinders and UO₂ drums. The performance of typical NDA systems used in safeguards applications is periodically published by the International Atomic Energy Agency (IAEA) as part of a document usually referred to as “International Target Values” (ITV). Historically, several international institutions and laboratories, including ABACC, have contributed with the IAEA in sharing measurement data and discussing performance values. Since the latest

version of the ITV was issued in 2010 and does not include uncertainty estimates for medium energy resolution gamma spectrometers, this paper aims to contribute with useful data for establishing reliable uncertainty estimates that could be included in the next edition of the ITV.

1. INTRODUCTION

Measurements of ^{235}U enrichment by non-destructive assay (NDA) methods based on gamma-ray spectrometry are routinely performed by nuclear safeguards inspectorates for verification of the declared value in “infinitely” thick uranium samples during on-site inspections at fuel fabrication, conversion and enrichment plants. Among several advantages, the methods allow for prompt obtention of the results. The most frequently used options are based on high- and low-resolution systems using high-purity germanium (HPGe) semiconductor and sodium iodide (NaI) scintillation detectors, respectively. More recently, Cerium-doped Lanthanum Bromide ($\text{LaBr}_3(\text{Ce})$) scintillation detectors have been tested and approved for regular use by the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) and the International Atomic Energy Agency (IAEA) as a medium-resolution option of similar usability, i.e., detector size and operation at room temperature, and efficiency, but with better stability and energy resolution than NaI. For spectra evaluation and calculation of the enrichment results, the NaIGEM code [1, 2] has been used. It employs fitting procedures to determine the intensity of gamma-rays emitted by ^{235}U in the region 120 – 300 keV, as well as interferences caused by high-energy gamma-rays from ^{238}U decay and low-angle Compton scattering in the same energy region. If a significant amount of ^{238}Th is also present in the sample (commonly observed in reprocessed uranium or natural Th), the intensity of the corresponding 239 keV decay peak may be relevant and then the code is capable of computing. At the end, the intensity of the most prominent 186 keV peak from ^{235}U decay is determined and used to derive the enrichment of the measured sample based on previous calibration of the measurement system with well-known reference samples. The code was originally developed for analyzing only NaI spectra, but the latest versions are capable of interpreting spectra collected with LaBr_3 detectors as well. Some studies [3] have already been conducted in order to assess the performance of such detector for enrichment determinations in a laboratory environment. In this paper we discuss performance results obtained under conditions found in actual field safeguards inspections where additional limitations and difficulties are commonly faced.

2. MEASUREMENT SYSTEMS

The standard LaBr_3 detector currently used by ABACC is a Brilliance 380 model, which has a 38 mm diameter by 38 mm length cylindrical crystal produced by Saint Gobain [4]. In order to minimize background interference and establish a well-defined measurement geometry, 10 mm lead lateral shielding and frontal collimation (25 mm dia.) are used. The selected digital multichannel analyzer (MCA) is the model Base-527 by GBS Elektronik GmbH [5], a compact unit designed to compose a single cylindrical piece when it is connected to preamplifier pins on the back of the detector piece. The MCA may be controlled by means of a dedicated cost-free software named WinSPEC, also provided by GBS. For all measurements, the MCA is adjusted for collecting gamma spectra with 512 channels and energy calibrated with slope of 0.62 keV/Ch. Enrichment calibration requires a single measurement. A set of certified reference materials composed by five aluminum cans containing about 200 grams of U_3O_8 in each with enrichment ranging from depleted to 4.46

^{235}U wt% is used [6]. Depending on the samples to be measured in the field, additional stainless steel or monel alloy attenuators may be placed between the bottom of the reference material and the collimator opening in order to better simulate actual measurement geometry. This is of particular importance when dense and thick-walled containers like large UF_6 cylinders are measured, otherwise the results may be affected by significant biases that arise from improper correction of the gamma-ray attenuation in the container wall in comparison with the reference material. In case of fuel rods, working standards of similar geometry are used for calibration. Typical calibration measurements, in a laboratory, are collected with 30- or 60-min counting times. The NaIGEM code version 2.1.4 [2] is used for data analysis. A digital ultrasonic thickness gauge capable of providing readings with resolution of 0.1 mm or better (ABACC currently uses the model DM4 DL by Krautkramer) is used to determine the wall thickness of the measured item, which is essential for the code to properly correct gamma-ray intensities for wall attenuation. The material type must also be known.

The IAEA uses a slightly different MRGS system, but also based on the NaIGEM code for data analysis. The field experience has demonstrated that both ABACC and IAEA systems provide similar performances.

3. FIELD RESULTS

Drums containing about 220 kg of natural UO_2 are routinely handled at some conversion and the fuel fabrication plants. During safeguards inspections, the drums are verified by weighing using an electronic balance and enrichment measurements using a portable MRGS system as described in session 2. Measurement live time is set at 300 seconds. The uncertainty associated with the declared value is assumed to be negligible.

Table 1 presents the summary results obtained during five consecutive years, including some statistical evaluation. The analysis of variance (ANOVA) method [7] was used to estimate two uncertainty components: between different years and within a single year. The total uncertainty is given by the square root of the sum of squares of these two components. For comparison purposes, the typical uncertainty value for LRGS systems (NaI) is 5.8% according to international target values obtained from historical evaluation of actual measurement data collected during inspections and published by the IAEA [8]. The observed total uncertainty was 2.9%, indicating that MRGS provided improved performance (50% better) in comparison with LRGS for this application.

Table 1: Summary Results - Declared to Measured (O-I) % Deviation for Enrichment Measurements of Natural UO₂ Drums by MRGS.

Year	O-I Difference (% rel.) (average per year)	O-I Difference (% rel.) (Std deviation per year)
#1	-0.37	2.81
#2	1.64	3.71
#3	0.89	2.18
#4	-0.38	2.85
#5	0.51	1.42
Statistical Parameters	Total Number of Measurements = 117 Overall O-I Difference (% rel.) = 0.35 Overall Standard Deviation = 2.9%	
Uncertainty Estimates (ANOVA)	u_{between} = 0.7% u_{within} = 2.8% u_{total} = 2.9%	

Enrichment of drums containing LEU clean scrap are also measured using MRGS. However, the total number of measurements available is smaller than in the previous case. In addition, the uncertainty associated with the declared value cannot be considered negligible due to important sources of errors such as the use of nominal values and heterogeneity in the physical form of the material in the drum.

Table 2 presents the summary results obtained during three consecutive years, including some statistical evaluation. For comparison purposes, the typical uncertainty value for LRGS systems (NaI) is 3.6 [8]. The observed total uncertainty for enrichment measurements with MRGS was 4.4%. However, it includes contributions from both the operator and the inspectorate measurements. Assuming these contributions are of similar magnitude, one can conclude that MRGS provided performance results similar to LRGS.

Table 2: Summary Results - Declared to Measured (O-I) % Deviation for Enrichment Measurements of Low Enriched Scrap in Drums by MRGS.

Year	O-I Difference (% rel.) (average per year)	O-I Difference (% rel.) (Std deviation per year)
#1	-0.31	2.78
#2	-1.31	5.97
#3	0.87	2.14
Statistical Parameters	Total Number of Measurements = 14 Overall O-I Difference (% rel.) = 0.34 Overall Standard Deviation = 4.0%	
Uncertainty Estimates (ANOVA)	u_{between} = 0.6% u_{within} = 4.4% u_{total} = 4.4%	

LEU fuel rods enriched from 0.85 to 4.25 ²³⁵U wt% are another type of item commonly measured in fuel fabrication plants. Table 3 presents the summary results obtained during three consecutive years, including some statistical evaluation. For comparison purposes, the

typical uncertainty value for LRGS systems (NaI) is 3.2 [8]. The observed total uncertainty for enrichment measurements with MRGS was also 3.2%.

Table 3: Summary Results - Declared to Measured (O-I) % Deviation for Enrichment Measurements of Low Enriched Fuel Rods by MRGS.

Year	O-I Difference (% rel.) (average per year)	O-I Difference (% rel.) (Std deviation per year)
#1	-2.04	2.87
#2	-0.20	3.59
#3	-2.23	1.80
Statistical Parameters	Total Number of Measurements = 14 Overall O-I Difference (% rel.) = -1.31 Overall Standard Deviation = 2.9%	
Uncertainty Estimates (ANOVA)	u_{between} = 1.1% u_{within} = 3.0% u_{total} = 3.2%	

4. CONCLUSIONS

The performance of non-destructive enrichment measurements based on gamma-ray spectrometry using medium resolution LaBr₃ detectors and spectra analysis by a code that uses peak fitting algorithm (NaIGEM) during actual safeguards inspections in conversion and fuel fabrication plants has been evaluated by ABACC. Typical items are drums containing uranium oxide powders, scraps, as well fuel rods. The MRGS method has demonstrated to offer better performance in comparison the obsolete LRGS based on NaI detectors for measurements under good measurement conditions. Measurements of drums containing pure natural UO₂ were able to provide results with 50% better uncertainties than LRGS. On the other hand, for items subject to additional uncertainties in the declared values, i.e., scrap, the observed performances were similar. Future investigations aiming at quantifying item-specific sources of uncertainties for separation from the contributions associated exclusively with the measurement method are planned. This is a common practice in the area of destructive analysis and should be more explored also in NDA applications.

ABACC has successfully completed the migration from the low to the medium resolution gamma spectrometry method for enrichment measurements using LaBr₃ detectors and the NaIGEM code. The establishment of typical measurement uncertainties for the MRGS method in different applications is currently being discussed by experts and users worldwide, including ABACC, under the coordination of the IAEA.

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PARTE II

Resúmenes de publicaciones en revistas científicas y técnicas

SELF-CONSISTENT SCREENED HYDROGENIC MODEL BASED ON THE AVERAGE-ATOM MODEL: COMPARISONS WITH ATOMIC CODES AND PLASMA EXPERIMENTS *

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Abstract

Here we present a self-consistent relativistic screened-hydrogenic model (SHM) based on the average-atom model (AAM) for effective calculation of the energy levels of many-electron atoms immersed in plasmas. In addition, we use diverse atomic codes using the configuration interaction method, to calculate the influence of electron density and temperature on the spectra of the diverse ionic states present in a plasma focus device, as well as in other dense plasma systems. The parameters of the AAM are introduced in a coupled system of Saha equations to find the densities and abundances of the different ions to obtain the effective charges and eigenenergies of hydrogenic bound states within the framework of a self-consistent Ion Sphere Model. The results of our calculations are compared with experimental data obtained by different authors and some discrepancies between theoretical and experimental spectra are explained.

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SOME APPLICATIONS OF PERTURBATION THEORY IN ATOMIC PHYSICS *

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Abstract

In this work we show that the simplest results of the time independent perturbation theory (TIPT) can be used for the systematization of many experimental data from Atomic Physics. In particular, we will see applications to alkaline metals and different types of isoelectronic sequences, comparing the experimental data stored in the databases with simple parametrizations arising from the TIPT.

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FULL-ENERGY PEAK DETERMINATION FROM TOTAL EFFICIENCY AND PEAK-TO-TOTAL RATIO CALCULATIONS *

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Abstract

The aim of this work is to examine, from a theoretical point of view, the full-energy peak determination by starting from total efficiency and peak-to-total calculations, which are widely used in gamma-ray spectrometry. The detectors here examined include five different sodium iodide NaI(Tl) detectors and three high purity germanium HPGe detectors. The full-energy peak efficiency was determined both analytically and numerically. In some cases, the discrepancy between the experimental values was less than 6%. Some differences between semi-empirical calculations, analytical calculations, and Monte Carlo methods are shown. In addition, some of these results were compared with available experimental data.

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MONTE CARLO CALCULATION OF ORGAN DOSE COEFFICIENTS FOR INTERNAL DOSIMETRY: RESULTS OF AN INTERNATIONAL INTERCOMPARISON EXERCISE *

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Abstract

EURADOS Working Group 6 has organized an intercomparison exercise on the use of the ICRP Reference Computational Phantoms with radiation transport codes. This paper summarizes the results of a specific task from the intercomparison exercise modelling internal radiation sources. The quantities to be calculated were absorbed fractions and specific absorbed fractions for monoenergetic photon and electron sources as well as S-values for two radionuclides in four source organs. Twelve participants from eleven countries participated in this specific task using the Monte Carlo radiation transport codes FLUKA, Geant4, the MCNP code family, PenEasy, TRIPOLI-4 and VMC. Although some participants provided initial solutions in good agreement with the master solution evaluated by the organizers, differences of factors or even orders of magnitude were also found. Following feedback from the organizer, most participants submitted revised solutions that were mostly in better agreement with the master solution, although this was not always the case. Some initial and revised results are discussed in detail in this paper, and the reasons of mistakes are described as far as they were revealed by the participants. A full account of all results is presented in specific annexes as supplemental material.

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DETAILED DOSIMETRY CALCULATION FOR *IN-VITRO* EXPERIMENTS AND ITS IMPACT ON CLINICAL BNCT *

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Abstract

Purpose: Boron Neutron Capture Therapy (BNCT) is a form of hadrontherapy based on the selective damage caused by the products of neutron capture in ^{10}B to tumour cells. BNCT dosimetry strongly depends on the parameters of the dose calculation models derived from radiobiological experiments. This work aims at determining an adequate dosimetry for in-vitro experiments involving irradiation of monolayer-cultured cells with photons and BNCT and assessing its impact on clinical settings.

M&M: Dose calculations for rat osteosarcoma UMR-106 and human metastatic melanoma Mel-J cell survival experiments were performed using MCNP, transporting uncharged particles for KERMA determinations, and secondary particles (electrons, protons, ^{14}C , ^4He and ^7Li) to compute absorbed dose in cultures. Dose-survival curves were modified according to the dose correction factors determined from computational studies. New radiobiological parameters of the photon isoeffective dose models for osteosarcoma and metastatic melanoma tumours were obtained. Dosimetry implications considering cutaneous melanoma patients treated in Argentina with BNCT were assessed and discussed.

Results: KERMA values for the monolayer-cultured cells overestimate absorbed doses of radiation components of interest in BNCT. Detailed dose calculations for the osteosarcoma irradiation increased the relative biological effectiveness factor RBE1% of the neutron component in more than 30%. The analysis based on melanoma cases reveals that the use of survival curves based on KERMA leads to an underestimation of the tumour doses delivered to patients.

Conclusions: Considering detailed dose calculation for in-vitro experiments significantly impact on the prediction of the tumor control in patients. Therefore, proposed methods are clinically relevant.

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PARTE III

Publicaciones de la ARN

Dosis a miembros del público debido a las descargas de material radiactivo de las instalaciones argentinas

Amado, V.A. y Maizel, P.V.

DOSIS A MIEMBROS DEL PÚBLICO DEBIDO A LAS DESCARGAS DE MATERIAL RADIATIVO DE LAS INSTALACIONES ARGENTINAS

PERÍODO 2016-2018

Amado, V.A. y Maizel, P.V.

Autoridad Regulatoria Nuclear

RESUMEN

En este trabajo se presentan las dosis a miembros del público debido a las descargas de material radiactivo al ambiente informadas durante el período 2016 a 2018. Las mismas corresponden a la operación de instalaciones argentinas que tienen valores autorizados de descargas.

1. INSTALACIONES

Se consideraron las instalaciones argentinas de la Tabla 1, que actualmente cuentan con valores autorizados de descargas al ambiente. Las mismas poseen licencia de operación vigente a 2019.

Instalaciones Clase I	Ubicación	Entidad Responsable
Central Nuclear Atucha Unidad I (CNA U-I)	Sitio Atucha, Lima, Bs. As.	Nucleoeléctrica Argentina S.A. (NA-SA)
Central Nuclear Atucha Unidad II (CNA U-II)	Sitio Atucha, Lima, Bs. As.	NA-SA
Central Nuclear Embalse (CNE)	Embalse de Río Tercero, Córdoba	NA-SA
Reactor de Investigación RA-3	Centro Atómico Ezeiza (CAE), Bs. As.	Comisión Nacional de Energía Atómica (CNEA)
Reactor de Investigación RA-6	Centro Atómico Bariloche (CAB), Río Negro	CNEA
Ciclotrón de Producción de Radioisótopos (CPR)	CAE, Bs. As.	CNEA
Planta de Producción de Radioisótopos por Fisión (PPRF)	CAE, Bs. As.	CNEA
Planta de Producción de Radioisótopos (PPR)	CAE, Bs. As.	CNEA
Fábrica de Elementos Combustibles Nucleares (FECN)	CAE, Bs. As.	Combustibles Nucleares Argentinos S.A. (CONUAR)
Instalaciones Clase II		
Planta de Producción de Dióxido de Uranio (PPUO ₂)	Córdoba	Dioxitek S.A.

Tabla 1. Instalaciones argentinas consideradas.

2. DESCARGAS RADIATIVAS AL AMBIENTE

A continuación se muestran los valores correspondientes a las descargas radiactivas al ambiente de las instalaciones argentinas de la Tabla 1. Se discriminaron en líquidas y gaseosas; y por grupos de radionucleidos. Las mismas fueron realizadas en los años 2016, 2017 y 2018 (Tabla 2, Tabla 3 y Tabla 4; respectivamente).

Las Figuras 1, 2 y 3 muestran la composición de las descargas de efluentes radiactivos al ambiente del período 2016-2018 para la Central Nuclear Atucha Unidad I (CNA U-I), la Central Nuclear Atucha Unidad II (CNA U-II) y la Central Nuclear Embalse (CNE), respectivamente. En las mismas se observa la importante contribución del tritio a las descargas totales, en concordancia con las características de las centrales nucleares. Para el período 2016-2018 la misma fue, en promedio, de 97,4% para la CNA U-I, de 93,2% para la CNA U-II y de 99,9% para la CNE. La mayor fracción del valor autorizado de descarga que la CNA U-I liberó al ambiente en el período 2016-2018 fue de 9,1% (año 2017). Para CNA U-II, el mayor valor fue de 9,2% (año 2018). En el primer caso se debió a la descarga líquida de tritio, mientras que en el segundo caso correspondió a la descarga gaseosa de tritio. En el caso de CNE, la mayor fracción del valor autorizado de descarga liberado al ambiente fue de 6,3%, debido a la descarga líquida de tritio (año 2016). Cabe destacar que esta central se encontró en parada debido al proyecto de extensión de su vida útil, durante todo el período analizado.

Instalación	Descargas 2016 (Bq)									
	Líquidas				Gaseosas					
	³ H	Emisores β/γ	Emisores α	U natural	Gases Nobles	³ H	Yodos	¹⁴ C	U natural	Otros
CNA U-I	1,3 10 ¹⁵	7,9 10 ¹⁰	2,8 10 ⁸	-	9,2 10 ¹³	4,3 10 ¹⁴	3,4 10 ⁹	5,1 10 ¹¹	-	3,2 10 ⁷
CNA U-II	2,0 10 ¹⁴	5,3 10 ¹⁰	6,2 10 ⁷	-	4,7 10 ¹³	1,9 10 ¹⁴	1,9 10 ⁹	5,2 10 ¹⁰	-	3,7 10 ⁷
CNE	2,3 10 ¹⁴	3,7 10 ⁹	-	-	-	1,8 10 ¹⁴	4,2 10 ⁰	-	-	1,0 10 ²
RA-3	-	8,1 10 ⁶	-	-	2,6 10 ¹³	-	8,8 10 ⁵	-	-	2,8 10 ⁷
RA-6	-	1,1 10 ⁶	-	-	1,5 10 ¹⁰	-	-	-	-	-
CPR*	-	-	-	-	-	-	-	-	-	4,0 10 ¹⁰
PPRF	-	-	-	-	9,9 10 ¹²	-	-	-	-	-
PPR	-	-	-	-	-	-	7,2 10 ⁸	-	-	-
FECN	-	-	-	2,5 10 ⁵	-	-	-	-	5,4 10 ⁴	-
PPUO ₂ **	-	-	-	5,6 10 ⁷	-	-	-	-	1,7 10 ⁴	-

Tabla 2. Descargas realizadas en 2016, informadas por el operador.

*La descarga radiactiva del CPR corresponde a F-18.

**Para la PPUO₂, la contribución del U natural no se consideró dentro del grupo de emisores α sino en forma independiente.

Instalación	Descargas 2017 (Bq)									
	Líquidas				Gaseosas					
	³ H	Emisores β/γ	Emisores α	U natural	Gases Nobles	³ H	Yodos	¹⁴ C	U natural	Otros
CNA U-I	1,8 10 ¹⁵	8,1 10 ¹⁰	3,0 10 ⁸	-	1,9 10 ¹³	5,3 10 ¹⁴	3,7 10 ⁸	4,7 10 ¹¹	-	7,9 10 ⁷
CNA U-II	5,9 10 ¹⁴	8,2 10 ¹⁰	7,0 10 ⁷	-	3,8 10 ¹³	3,8 10 ¹⁴	2,8 10 ⁹	2,9 10 ¹¹	-	3,9 10 ¹⁰
CNE	6,3 10 ¹³	8,9 10 ⁹	-	-	2,6 10 ⁸	1,3 10 ¹⁴	2,1 10 ⁰	0	-	8,6 10 ¹
RA-3	-	-	-	-	4,2 10 ¹³	-	1,0 10 ⁶	-	-	3,9 10 ⁷
RA-6	-	1,3 10 ⁷	-	-	1,5 10 ¹⁰	-	-	-	-	-
CPR*	-	-	-	-	-	-	-	-	-	1,2 10 ⁹
PPRF	-	-	-	-	9,1 10 ¹²	-	-	-	-	-
PPR	-	-	-	-	-	-	1,1 10 ⁹	-	-	-
FECN**	-	-	-	1,2 10 ⁵	-	-	-	-	7,7 10 ⁴	-
PPUO ₂ ***	-	-	2,4 10 ⁴	9,4 10 ⁸	-	-	-	-	1,1 10 ⁷	2,3 10 ¹

Tabla 3. Descargas realizadas en 2017, informadas por el operador.

*La descarga radiactiva del CPR corresponde a F-18.

**La FECN dejó de realizar descargas líquidas al ambiente a partir de Agosto de 2017.

***Para la PPUO₂, la contribución del U natural no se consideró dentro del grupo de emisores α sino en forma independiente.

Instalación	Descargas 2018 (Bq)									
	Líquidas				Gaseosas					
	³ H	Emisores β/γ	Emisores α	U natural	Gases Nobles	³ H	Yodos	¹⁴ C	U natural	Otros
CNA U-I	1,3 10 ¹⁵	1,1 10 ¹¹	3,4 10 ⁸	-	3,6 10 ¹³	4,9 10 ¹⁴	8,7 10 ⁶	4,6 10 ¹¹	-	9,8 10 ⁶
CNA U-II	3,2 10 ¹⁴	1,3 10 ¹¹	6,9 10 ⁷	-	4,6 10 ¹³	4,2 10 ¹⁴	6,9 10 ⁸	4,3 10 ¹¹	-	3,0 10 ⁷
CNE	9,4 10 ¹³	4,7 10 ⁹	-	-	-	2,6 10 ¹⁴	2,3 10 ⁰	-	-	5,2 10 ¹
RA-3	-	1,1 10 ⁷	-	-	1,0 10 ¹⁴	-	2,9 10 ⁶	-	-	5,5 10 ⁷
RA-6	-	1,1 10 ⁷	-	-	1,4 10 ¹⁰	-	-	-	-	-
CPR [*]	-	-	-	-	-	-	-	-	-	4,0 10 ⁷
PPRF	-	-	-	-	9,2 10 ¹²	-	-	-	-	-
PPR	-	-	-	-	-	-	1,6 10 ⁹	-	-	-
FECN	-	-	-	-	-	-	-	-	5,8 10 ⁴	-
PPUO ₂ ^{**}	-	-	4,6 10 ⁶	8,1 10 ⁸	-	-	-	-	9,1 10 ⁶	1,0 10 ²

Tabla 4. Descargas realizadas en 2018, informadas por el operador.

* La descarga radiactiva del CPR corresponde a F-18.

** Para la PPUO₂, la contribución del U natural no se consideró dentro del grupo de emisores α sino en forma independiente.

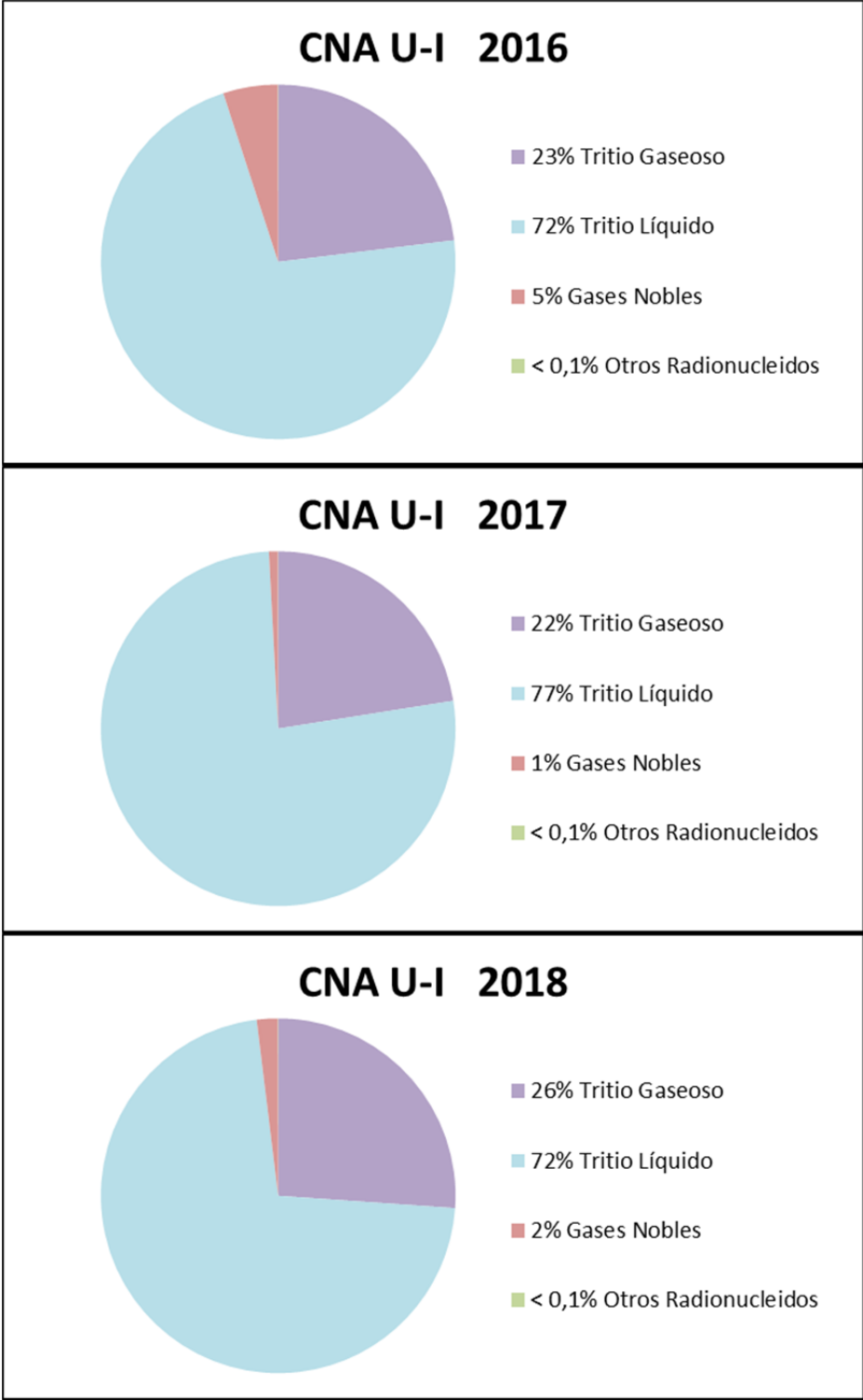


Figura 1. Composición de las descargas al ambiente de CNA U-I realizadas en el período 2016-2018.

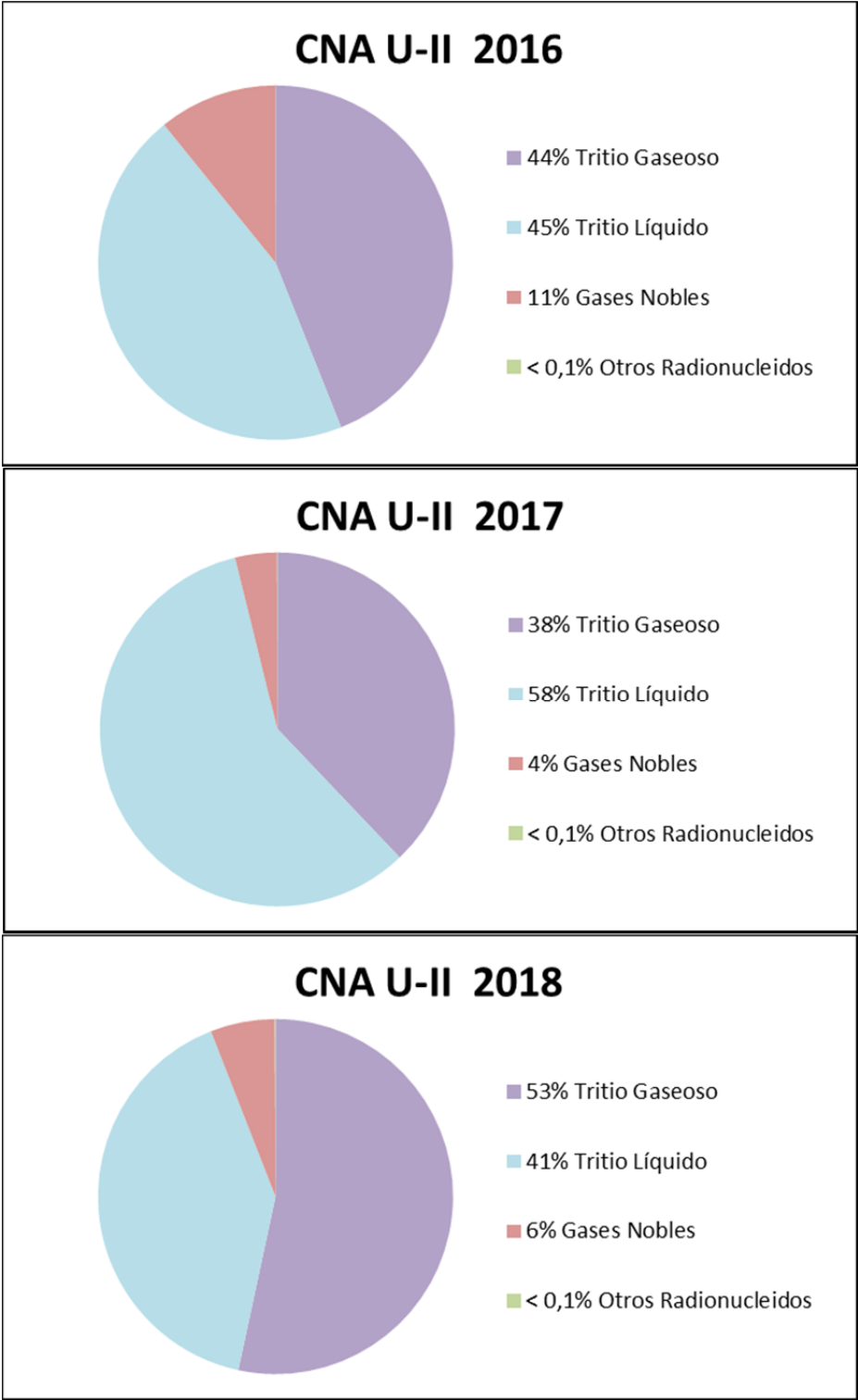


Figura 2. Composición de las descargas al ambiente de CNA U-II realizadas en el período 2016-2018.

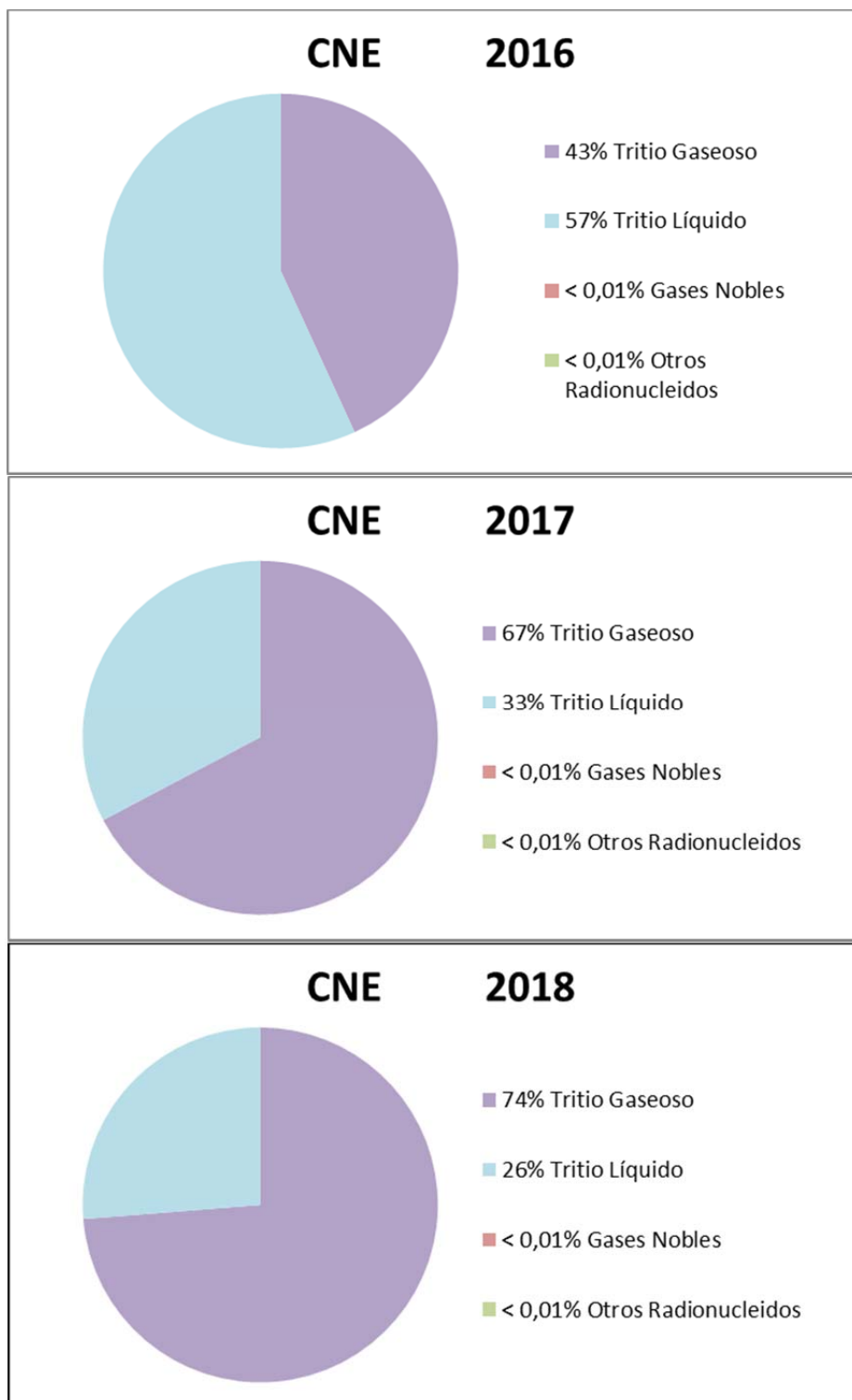


Figura 3. Composición de las descargas al ambiente de CNE realizadas en el período 2016-2018

3. DOSIS A MIEMBROS DEL PÚBLICO

Para evaluar la dosis efectiva anual en la población se utiliza el concepto de persona representativa (PR) [1]. Se calculó la dosis efectiva en la persona representativa asociada a cada instalación (ver 3.1), en la etapa operativa, y se aplicaron los modelos de evaluación de dosis para descargas rutinarias vigentes a 2018. Estos son: PC CREAM08 (Consequences of Releases to the Environment Assessment Methodology) [2], para descargas gaseosas; y Dosis Líquida [3] para descargas líquidas (ver 3.2). Finalmente, en la sección 3.3 se muestran los resultados de la evaluación.

3.1 Persona Representativa

En la Tabla 5 se detalla la persona representativa del Sitio Atucha, CNE, CAB y CAE para operación normal. En todos los casos se asumió que la PR corresponde a un adulto.

Instalación	Ubicación de la PR	Lugar de procedencia de los alimentos	Cuerpo de agua en el que se realizan las descargas líquidas
Sitio Atucha	1,6 km O	100% de vegetales y frutas, ubicación de la PR 100% de carne y leche, ubicación Tambo a 2,7 km S	Río Paraná de las Palmas
CNE	1,5 km NE (hasta 2016) 1,22 km NE (a partir de 2017 [4])	50% de vegetales y frutas, ubicación de la PR 100% de carne y leche, ubicación Tambo a 2 km ESE	Lago Embalse de Río Tercero
CAB	1 km NE	100% ubicación de la PR	Arroyo Gutiérrez (pasa previamente por un lecho nitrificante)
CAE	1 km SO	100% ubicación de la PR	Arroyo Aguirre

Tabla 5. Persona representativa del Sitio Atucha, CNE, CAB y CAE.

Se tuvieron en cuenta los hábitos y consumos definidos en [5], excepto en el caso del consumo de pescado para la persona representativa del CAE. En este último caso se asumió una tasa de ingestión menor debido a las características del Arroyo Aguirre.

Como se mencionó previamente, es necesario considerar que si bien la dosis al público debido a las descargas de la CNE se calculó para la PR asociada a la operación normal, la central se encontró en parada durante todo el período analizado.

3.2 Modelos de Evaluación de Dosis

3.2.1 PC CREAM 08

El modelo PC CREAM 08 [2] permite evaluar las consecuencias radiológicas de la descarga de efluentes radiactivos durante la operación normal de instalaciones nucleares y radiactivas. Posee un módulo principal, llamado ASSESSOR, y módulos accesorios: PLUME, RESUS, GRANIS, FARMLAND, DORIS y dos modelos para descargas a río. Los módulos accesorios estiman la transferencia de radionucleidos al medio ambiente y la concentración de actividad en distintas matrices. El módulo principal utiliza la salida de los módulos accesorios permitiendo evaluar la dosis individual y la dosis colectiva.

El módulo PLUME considera un modelo de dispersión atmosférica de pluma gaussiana, que tiene en cuenta las condiciones meteorológicas, la rugosidad del terreno y las características físicas del radionucleido. La rosa de vientos que se utiliza puede ser uniforme o contener datos específicos del sitio, que se incorporan a las librerías del programa. Actualmente, las librerías del PC CREAM08 poseen archivos con los datos meteorológicos del sitio Atucha (aplicable a CNA U-I y CNA U-II) [6], CNE [6], CAE [7] y CAB [8].

Las vías de exposición asociadas a descargas gaseosas que contempla el programa son: inhalación, inhalación debido a resuspensión, ingestión de alimentos e irradiación externa debido a material depositado y a inmersión en la nube radiactiva.

3.2.2 Dosis Líquida

El modelo Dosis Líquida [3] empleado para descargas líquidas es un modelo compartimental basado en [9]. No considera explícitamente la progenie radiactiva, sino solo a través de los coeficientes dosimétricos. Estos están tomados de [10], para ingestión, y de [9] en el caso de irradiación externa debido a sedimentos.

Los factores dosimétricos por ingestión de [10] se basan en los límites recomendados en el ICRP 60 [11] y los valores de ponderación por radiación y tejido de esa publicación. Los valores son consistentes con los del ICRP 72 [12], basados a su vez en los del ICRP 30 [13]. En todos los casos, los coeficientes de dosis para un dado radionucleido incluyen su propia contribución y la de su progenie [12].

Los factores dosimétricos para irradiación externa de [9] están estimados a partir de la dosis equivalente debido a depósito superficial y considerando el factor de ponderación para piel. Además tienen en cuenta la progenie radiactiva relevante durante 30 años, que es el período de operación asumido para la instalación.

Las vías de exposición asociadas a descargas líquidas que contempla el modelo son: ingestión de agua y de pescado, e irradiación externa debido a los sedimentos de la orilla.

3.2.2.1 Dosis Líquida para CNE

Debido a las condiciones meteorológicas de la zona de Embalse es necesario recurrir al riego artificial para llevar adelante la producción de alimentos. Por esta razón; desde 2009, el Modelo Dosis Líquida para tritio incluye la vía de ingestión debido a vegetales y frutas regadas con agua del Lago Embalse de Río Tercero.

3.3 Resultados

La Tabla 6 muestra la dosis efectiva anual en la persona representativa de cada instalación, en cada año del período 2016-2018. Se detalla la dosis efectiva anual debido a cada tipo de descarga (gaseosa o líquida) y debido a la suma de ambas (total).

Instalación	Dosis Efectiva Anual (mSv/a)								
	Año 2016			Año 2017			Año 2018		
	Líquidas	Gaseosas	Total	Líquidas	Gaseosas	Total	Líquidas	Gaseosas	Total
CNA U-I	$3,7 \cdot 10^{-4}$	$3,9 \cdot 10^{-3}$	$4,3 \cdot 10^{-3}$	$5,3 \cdot 10^{-4}$	$4,6 \cdot 10^{-3}$	$5,1 \cdot 10^{-3}$	$5,2 \cdot 10^{-4}$	$4,3 \cdot 10^{-3}$	$4,9 \cdot 10^{-3}$
CNA U-II	$1,6 \cdot 10^{-4}$	$2,0 \cdot 10^{-3}$	$2,2 \cdot 10^{-3}$	$3,9 \cdot 10^{-4}$	$3,6 \cdot 10^{-3}$	$4,0 \cdot 10^{-3}$	$4,7 \cdot 10^{-4}$	$4,0 \cdot 10^{-3}$	$4,5 \cdot 10^{-3}$
CNE	$6,0 \cdot 10^{-3}$	$3,9 \cdot 10^{-4}$	$6,4 \cdot 10^{-3}$	$5,7 \cdot 10^{-3}$	$3,0 \cdot 10^{-4}$	$6,0 \cdot 10^{-3}$	$4,2 \cdot 10^{-3}$	$6,1 \cdot 10^{-4}$	$4,8 \cdot 10^{-3}$
RA-3	$2,5 \cdot 10^{-3}$	$1,1 \cdot 10^{-3}$	$3,6 \cdot 10^{-3}$	-	$1,7 \cdot 10^{-3}$	$1,7 \cdot 10^{-3}$	$1,5 \cdot 10^{-3}$	$4,3 \cdot 10^{-3}$	$5,8 \cdot 10^{-3}$
RA-6	$1,5 \cdot 10^{-4}$	$1,1 \cdot 10^{-6}$	$1,5 \cdot 10^{-4}$	$1,5 \cdot 10^{-3}$	$1,1 \cdot 10^{-6}$	$1,5 \cdot 10^{-3}$	$1,8 \cdot 10^{-3}$	$1,0 \cdot 10^{-6}$	$1,8 \cdot 10^{-3}$
CPR	-	$3,6 \cdot 10^{-6}$	$3,6 \cdot 10^{-6}$	-	$1,1 \cdot 10^{-7}$	$1,1 \cdot 10^{-7}$	-	$3,6 \cdot 10^{-9}$	$3,6 \cdot 10^{-9}$
PPRF	-	$3,8 \cdot 10^{-5}$	$3,8 \cdot 10^{-5}$	-	$3,3 \cdot 10^{-5}$	$3,3 \cdot 10^{-5}$	-	$3,5 \cdot 10^{-5}$	$3,5 \cdot 10^{-5}$
PPR	-	$1,8 \cdot 10^{-4}$	$1,8 \cdot 10^{-4}$	-	$2,8 \cdot 10^{-4}$	$2,8 \cdot 10^{-4}$	-	$3,8 \cdot 10^{-4}$	$3,8 \cdot 10^{-4}$
FECN	$4,3 \cdot 10^{-6}$	$1,1 \cdot 10^{-7}$	$4,4 \cdot 10^{-6}$	$2,0 \cdot 10^{-6}$	$1,5 \cdot 10^{-7}$	$2,2 \cdot 10^{-6}$	-	$1,2 \cdot 10^{-7}$	$1,2 \cdot 10^{-7}$
PPUO ₂	$1,4 \cdot 10^{-5}$	$5,3 \cdot 10^{-7}$	$1,4 \cdot 10^{-5}$	$2,3 \cdot 10^{-4}$	$3,3 \cdot 10^{-4}$	$5,6 \cdot 10^{-4}$	$2,1 \cdot 10^{-4}$	$2,9 \cdot 10^{-4}$	$5,0 \cdot 10^{-4}$

Tabla 6. Dosis efectiva anual en la PR de cada instalación, para los años 2016 a 2018.

Las dosis efectivas anuales pueden diferir levemente respecto de las encontradas en los informes anuales [14,15,16]. Esto se debe a que, al momento de confeccionar cada informe (en el mes de diciembre), en general solo se cuenta con las descargas correspondientes a los tres primeros trimestres del año (teniendo que extrapolar los valores de las descargas anuales, por lo que no necesariamente coincidirán con las descargas anuales reales).

La Figura 4 muestra la dosis en la persona representativa debido a las descargas al ambiente, efectuadas en cada año del período 2016-2018, para el Sitio Atucha, CNE, CAB y CAE.

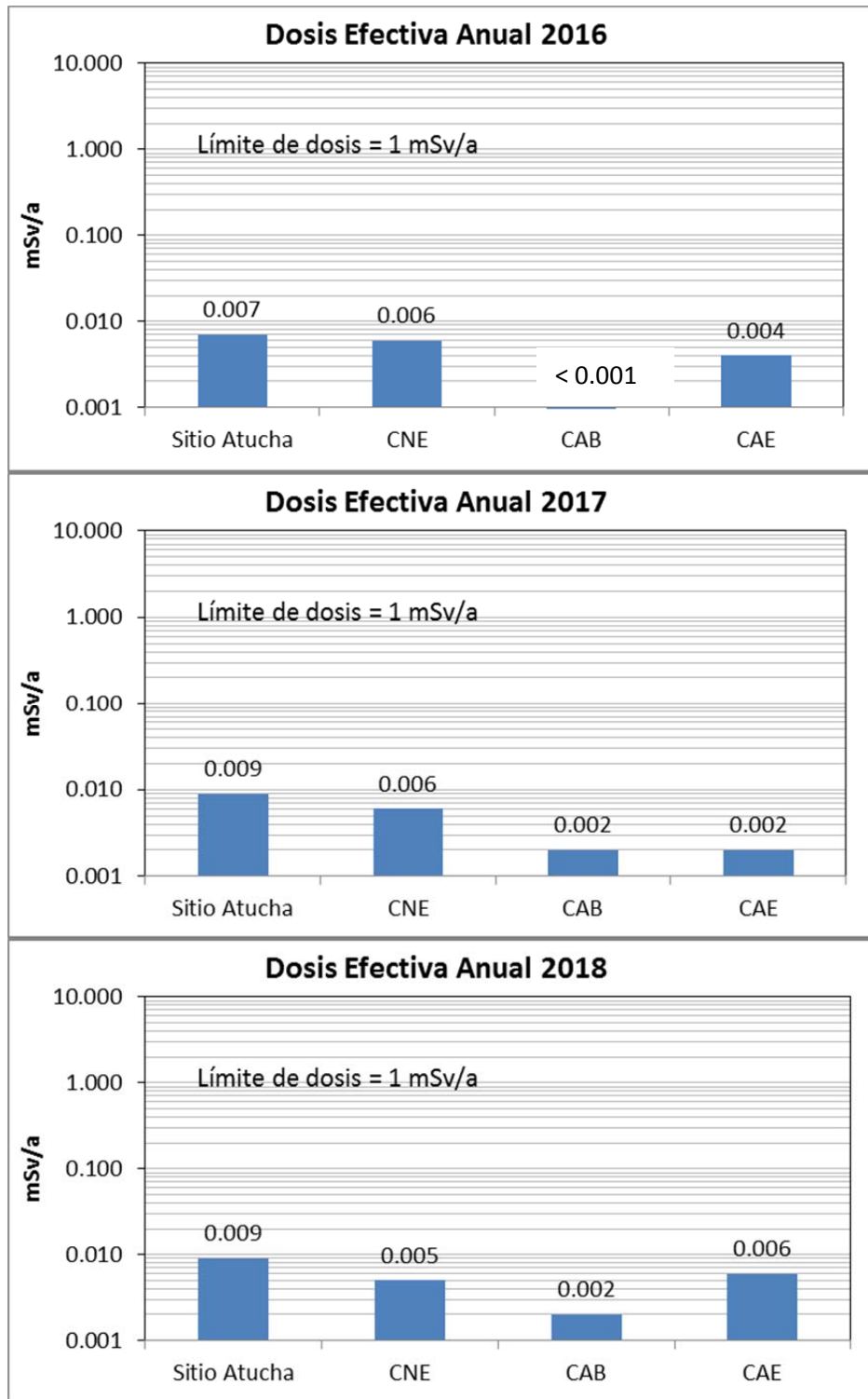


Figura 4. Dosis efectiva anual en la PR del Sitio Atucha, CNE, CAB y CAE para cada año del período 2016-2018.

Como se puede observar; las dosis efectivas en la PR de cada instalación debido a las descargas al ambiente efectuadas en 2016, 2017 y 2018, están muy por debajo del límite de dosis anual para público (1 mSv/a) y del valor de restricción de dosis [17]. En todos los casos, las dosis resultan menores al 1% del límite de dosis.

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Manual de No proliferación nuclear. Mujeres, liderazgo y redes en Argentina

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Duarte, M.L.; Garea, V. y Belinco, M.
Coordinación: Acosta, G.M.

MANUAL DE NO PROLIFERACIÓN NUCLEAR. MUJERES, LIDERAZGO Y REDES EN ARGENTINA *

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La ARN diseñó este proyecto con el objetivo de mejorar la visibilidad de las mujeres en el ámbito de la no proliferación nuclear y sus contribuciones concretas a nivel nacional e internacional, inspirar a mujeres jóvenes a ingresar y/o permanecer en este campo y fomentar una mejor y mayor representación de las mujeres en los diferentes niveles de gestión y en los puestos de liderazgo.

A tal fin, entre los meses de agosto y diciembre de 2021, un grupo multidisciplinario de la institución llevó a cabo el conversatorio virtual “Mujeres Argentinas en No Proliferación Nuclear. Representación y Liderazgo”, realizó entrevistas en profundidad a tres líderes argentinas en la materia y mantuvo una serie de intercambios con especialistas y expertas del sector nuclear.

Las deliberaciones sobre las distintas temáticas abordadas y las conclusiones extraídas se plasman en los siguientes capítulos, que son el resultado de una labor colaborativa y plural de representantes de la Agencia Brasileño-Argentina de Contabilidad y Control de Materiales Nucleares (ABACC), la Autoridad Regulatoria Nuclear, la Dirección de Seguridad Internacional, Asuntos Nucleares y Espaciales de la Cancillería Argentina (DIGAN), Women in Nuclear (WiN) Argentina y WiN Global.

* https://www.argentina.gob.ar/sites/default/files/manual_no_proliferacion_nuclear_digital.pdf

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