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INTEGRATED MANAGEMENT SYSTEM BEST PRACTICES IN RADIOECOLOGICAL LABORATORIES

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ABSTRACT

This paper presents a Master dissertation advancements with the target of studying the best practices, in order to give support to an IMS conceptual model –Integrated Management System (Quality, Environment, Work Safety and Health), applied to radioecological laboratories. The planning of the proposed research comprises the following stages: first stage - the bibliographic and documental survey in IMS; a survey and study of the applied standards (QMS NBR ISO 9000 (2005), NBR ISO 9001 (2008), NBR ISO 9004 (2000), EMS 14001(2004) and OHSMS OHSAS 18001 (2007) and OHSAS 18002 (2008)); identification and characterization in radioecological laboratories processes; a methodological study of better practices and benchmarking is carried out. In the second stage of the research, the development of a case study is forecast (qualitative research, with electronic questionnaires and personal interviews, when possible), preceded by a survey and selection of international and national radioecological laboratories to be studied and, in sequence, these laboratories should be contacted and agree to participate in the research; in a third stage, the construction of a matrix of better practices, which incur in the results able to subside an IMS conceptual model proposition for radioecological laboratories; the fourth and last stage of the research comprises the construction of a conceptual proposal of an IMS structure for radioecological laboratories. The first stage of the research results are presented concisely, as well as a preliminary selection of laboratories to be studied.

1 INTRODUCTION

In the process of quality systems evolution it can be observed a continuous search for improvement in management systems and their supporting tools. Organizations should be committed and develop their activities and businesses not only to meet requirements, regulations and customers, but also aiming to protect their collaborators and third parties safety and health, plus environmental requests, focusing on sustainability.

Studies conducted by the researchers, during the first phase of this research, depict the perception, in the organizations, of the necessity to evolve the management systems in a coordinated manner, uniting them in order to make the evaluation and feedback more efficient and effective, aiming the continuous improvement. The integration should be planned and implemented in a structured way. The IMS adoption has showed to be the promise of a solution for issues concerning management systems integration in the

organizations, proposing a unified structure, transparent and consistent for that, otherwise, could be an unnecessarily complicated set of management systems [1].
NBR ISO 9000:2005 [2] standard defines management system as a “set of inter-related or interactive elements to establish policy and targets, and to reach these targets”.

1.1 IMS - Integrated Management System (Quality, Environment, Health and Work Safety)

- The IMS comprises the three systems integration:
- Quality management system;
- Environmental management system;
- Health and work safety management system.

Integration targets:

- To offer products with quality, produced under conditions that not place any risk to the environment or the safety or health of the production line collaborators;
- To adopt a complete approach for the improvement of internal processes and to obtain a certification of all the systems, with only one audit;
- To reduce costs: through internal audits, implementation process, training, among other procedures.

2 STUDIES OF APPLICABLE STANDARDS, IDENTIFICATION AND CHARACTERIZATION OF PROCESSES IN RADIOECOLOGICAL LABORATORIES

2.1. Quality Management System

NBR ISO 9000:2005 [2] defines Quality Management System – “Management system to rule and control an organization in what refers to quality”. In Figure 1, the customers are observed to plan an important role in the definition of requirements as entries. The monitoring of the customers satisfaction requests the evaluation of information related to the perception, by the customers, of how (well) the organization has met their requirements.

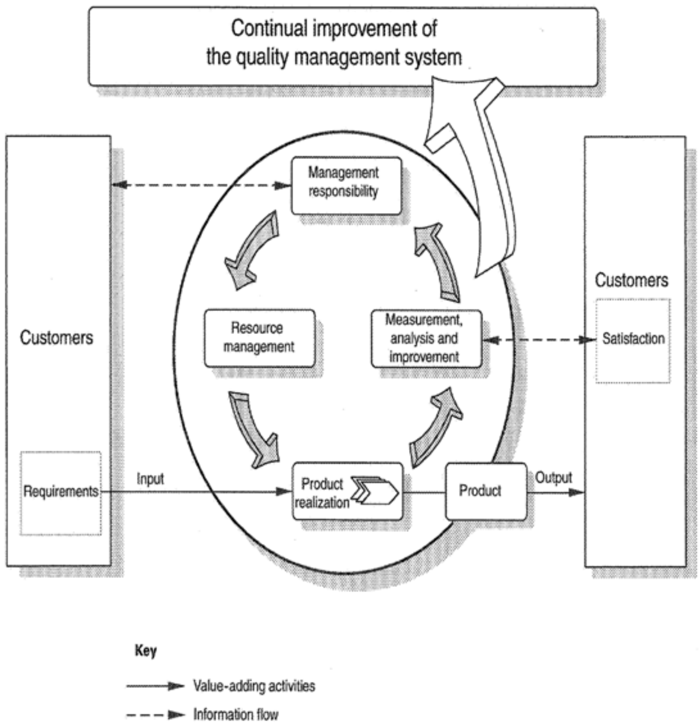

Figure 1 – Model of process-based Quality Management System [2]

2.2 Environmental Management System

NBR ISO 14000:2004 standard [3] defines environmental management as it follows: “it is the part of an organization management system used to develop and implement it is environmental policy and to manage its environmental aspects”. In Figure 2, a model of environmental management system in organizations is showed.

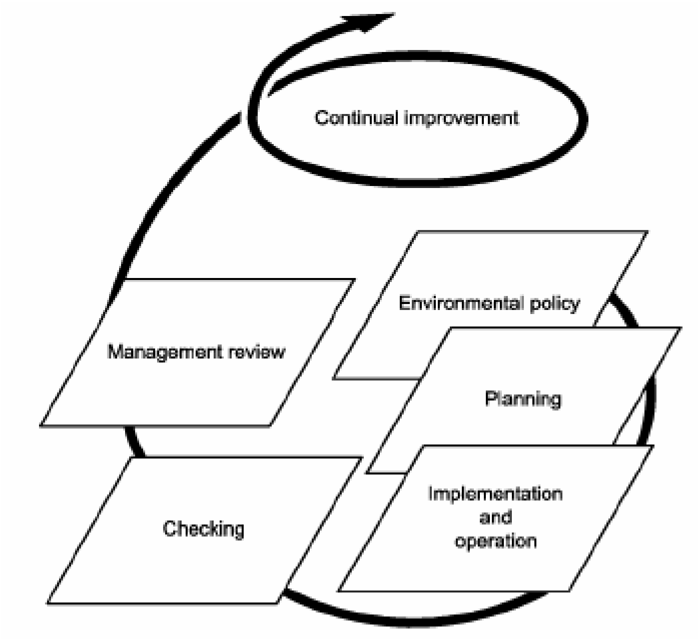

Figure 2 – Model of Environmental Management System [3]

Aquino [4] demonstrates that ISO 14000 standard may be applied to any organization and, not only, organizations able to cause strong environmental impacts. The author indicates that the cost involved in the certification is compensated by the benefits from it, and that for an ISO 9000 certified organization, the costs are even lower. With the application of ISO 14000, the organization improves its relations with the market requirements (certification), the government and the public, undergoing, forcefully, an organizational (re)structuration process that benefits all, and contributes to its competitiveness increase.

Zutshi and Sohal [5], for example, highlight the importance of the integration of the *Environmental Management System (EMS)* with the other systems implanted or under implantation in the organizations: "*to reduce ambiguity, duplication and wastage of resources (for instance the dollars, human and time), organizations, if practicable, should integrate their existing management systems and audits with EMS. The EMS implementation costs would also be reduced if organizations learn from their past experiences of implementing other systems (such as Quality Management System, Occupational Health and Safety System) and from the experiences of their peers and avoid repeating the same mistakes*".

2.3 Health and Work Safety Management System

ISO 18001 [6] defines occupational health and safety management systems as***:*** *"Part of an organization's management used to develop and implement its OH&S policy and manage its OH&S risk. A management system is a set of interrelated element's used to establish policy and objectives and to achieve those objectives. A management system includes organizational structure, planning activities (including, for example, risk assessment and the setting of objectives), responsibilities, practices, producers, the setting of objectives), responsibilities, practices, producers, processes and resources".*

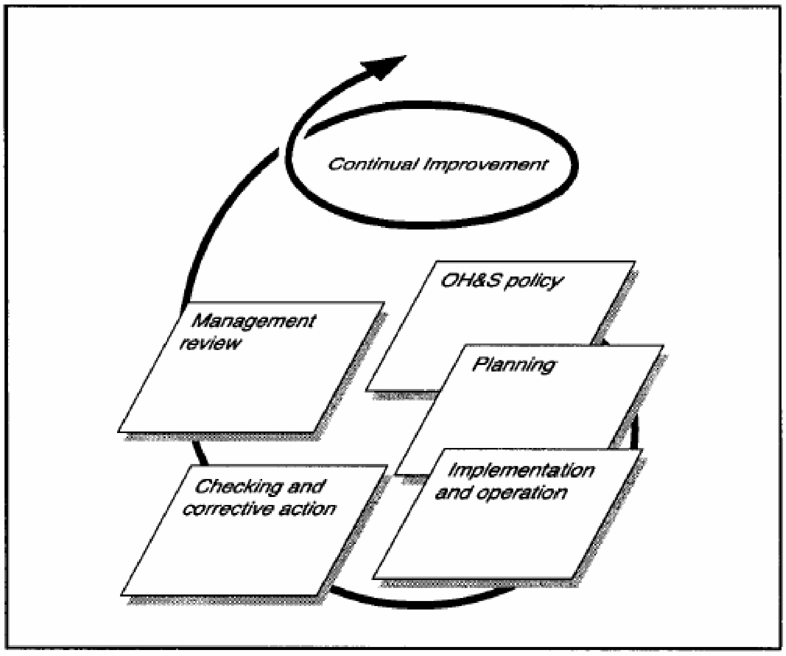

Figure 3 – Occupational Health and Safety Management System model [6]

OHSAS standard is based on the methodology known as PDCA (Plan-Do-Check-Act) [7] and specifies the requirements for a OH&S management system, allows an organization to control its accident and occupational diseases risks and to improve its performance, concerning safety and health aspects of all its collaborators.
In this study, OHSAS standard applies to:

- To establish a OH&S management system to eliminate or minimizes risks to people and third parts & stakeholders, who may be exposed to the OH&S dangers, associated to their activities; and
- To be assured of the OH&S policy the conformity (in the interest of this study, with intentions and general principles of an organization related to its OH&S performance, according to what has been formally expressed by the Top Management).

OH&S target
The OH&S target, concerning the OH&S performance, is what an organization establishes to itself.

Organization
Company, corporation, firm, enterprise, authority or institution, either part or the union of these, incorporated or not, public or private, with their own functions and administration.

2.4 Characterization of a Radioecological Laboratory, in the Interest of This Research

Organizations should be committed to develop their activities and business not only to meet their customers requirements and regulations, but also aiming to protect their collaborators and third parties safety and health, environmental requests, focusing the sustainability.

Radioecological laboratories carry out activities (classical chemical, instrumental and radiometric determinations, in environmental samples and effluents, water microbiological analyses, effluents ecotoxicity determination, genotoxicity assays of gaseous effluents, uranium analyses in urine samples for occupational radioprotection, among others), which are relevant to the environmental sustainability context.

As part of this stage of the research, the authors searched international and national references of radioecological laboratories to identify and characterize their structures, processes and research lines. Among the, the following Laboratories are highlighted.

2.4.1 International Atomic Energy Agency (IAEA) - Marine Environment Laboratories Monaco (MEL)

The IAEA Marine Environment Laboratory (IAEA-MEL) [10] in Monaco was established in 1961 as part of the IAEA Department of Research and Isotopes and is the only marine laboratory within the UN system. The laboratory exists as a working example, both of the high environmental awareness and concern of the International Atomic Energy Agency and of the marine scientific traditions and interests of the Principality of Monaco. It exemplifies the environmental care with which the world nuclear energy industry deals with its business, leading its competitors in ensuring understanding and control of its environmental consequences. It, also, establishes an example of an effective transfer of scientific industrial methods and advanced knowledge from developed countries to developing countries. Therefore, the State Members help to understand and protect the marine environment, plus coordinating technical aspects of oceans protection, training and assistance programs. MEL comprises the laboratories: Radiometric Laboratory (RML), Marine Environmental Studies Laboratory (MESL) e Radioecology Laboratory (REL). The REL laboratory is briefly described below.

2.4.1.1 REL – Radioecological Laboratory (REL)

The role of REL [11] is to foment marine processes knowledge, which determines the behavior and destination of radionuclides and other contaminants in the marine environment, with emphasis to the marine biosphere. Its activities refer to the radioecology, ecotoxicology and biogeochemical fields. REL has the commitment of giving assistance to the IAEA Member States, in particular to developing countries, with the use of nuclear and isotope techniques, to understand and evaluate the transfer or marine contaminants and environmental processes. The laboratory has the following research lines:

Bioaccumulation of marine contaminants

Various land-based industrial, mining, domestic and agricultural activities have been identified as the main sources of priority marine pollutants in coastal waters. Toxic pollutants derived from such activities are known to contaminate marine food chains and can have appreciable impact on sensitive ecosystems and food resources in coastal areas. The use of radionuclides, radiotracers and radio-labeled organic compounds offer unique tools for investigating and understanding the behavior and destination of these toxic substances (e.g., toxic heavy metals, PCBs and pesticides) in key temperate and tropical coastal ecosystems.

This is particularly important in regions where seafood and fish are a major part of the local diet and coral reef ecosystems are sensitive to pollutant impacts.

Characterization of bio-indicator species

The laboratory has been studying metal contamination in temperate and tropical environments to characterize and validate the bio-indicative value of several local marine species to be used in coastal monitoring programs. Presently, a particular effort is focused on tropical regions, where urbanization and industrialization are constantly growing, whereas there is little information available about possible associated impacts in the coastal environment.

Uranium, Thorium and Carbon fluxes

A nuclear technique using the disequilibrium between natural uranium and thorium in sea water is being employed to indirectly measure the removal of biologically produced carbon from the Upper Ocean and vertical transport to the depths. These data are being compared with carbon flux measurements using sediment traps. The project is also delineating the factors that govern the temporal and spatial variability of carbon flux in coastal shelf waters from different regions, as well as the sustainability of the Th-U technique for rapidly estimating carbon removal and downward flux. Radiotracer and isotopic signatures are also being used to establish the origin and transfer pathways of carbon in the marine environment.

Polonium-210 and Lead-210 in selected coastal environment

This project is investigating the bioaccumulation of the natural nuclides Polonium-210 and Lead-210, arising from hydrothermal and anthropogenic sources in coastal environments. The levels of these radionuclides in coastal regions are likely to be enhanced through natural geothermal venting, as well as from land based activities such as mining, oil refining and agrochemical applications. This work is improving the global database on their levels in the marine environment, and assessing their relative contributions to the overall ambient concentrations of natural radioactivity at specific coastal locations.

HABs - Harmful Algal Blooms

There are still important gaps in knowledge of the ways in which seafood become contaminated by HABs toxins improvements in our understanding will support better management of these economically valuable national and export industries.
MEL laboratories study some of these applications related to HAB radio-labeled toxins in their experimental aquariums. These nuclear techniques are used to measure these bio-toxins absorption directly in the aquatic means by the mussel “molluscan”, their subsequent distribution in the tissue, and how they can contaminate, through the food chain, fish and seafood predators, which may equally be consumed by human-beings. One of the predicted results consists in a better evaluation of the economical contribution that these technologies may bring, aiming to increase safety in the seafood intake and, consequently, to national and international commerce of these valuable products.

2.4.2 – RADIATION METROLOGY CENTER (RMC)

The RMC [12] has as a mission to develop and maintain standards and methods to measure ionizing radiation, generate scientific and technological knowledge, contribute to human resources formation and to improve the Brazilian population life quality.
To execute, consolidate and broaden its actions in radiation metrology, the Center activities are developed in the following laboratories/groups:

- Laboratório de Radiometria Ambiental (LRA) (Environmental Radiometry)
- Laboratório de Calibração de Instrumentos (LCI) (Calibration)
- Laboratório de Radiotoxicologia (LRT) (Radiotoxicology)
- Laboratório de Dosimetria Termoluminescente (LDT) (Thermoluminiscent Dosimetry)
- Laboratório de Materiais Dosimétricos (LMT) (Dosimetric Materials)
- Laboratório de Monitoração *in Vivo* (LMIV) (*in Vivo* Monitoring)
- Laboratório de Dosimetria de Doses Altas (LDA) (High doses Dosimetrty)
- Grupo de Cálculo de Dose (GCD) (Dose Calculation)

The LRA [13] has as its targets:

1) Research, development and characterization the dosimetric materials;
2) Development of methods for X-ray, beta and gamma external dosimetry;
3) Development of instrumental calibration, as well as reference ionization chambers, involving X-ray, beta and gamma radiation (Radiological Protection, Radiotherapy and Radio-diagnosis);
4) The establishment of methods and development of materials for high doses dosimetry, gamma, neutrons and electrons radiation, by optical absorption techniques, thermoluminiscence, TSEE and ionometry;
5) Development of methodologies for in vivo and in vitro internal monitoring of workers occupationally exposed;
6) Development of computational models and simulations, employing the Monte Carlo method in the calculation of internal and external doses;
7) Research and development in the areas of environmental protection, radioecology, and natural radionuclides application in environmental studies;
8) Services to meet public interest in the area of calibration, dosimetry, radiometry, radiochemistry and environmental radioprotection;
9) Services for the internal community;
10) Determination of radioactivity levels of liquid and gaseous effluents, generated by IPEN facilities;
11) Determination of the radioactivity levels in the samples defined in the IPEN environmental radiological monitoring program;
12) Internal individual monitoring, *in vivo* and *in vitro*;
13) Environmental personal and area dosimetry, calibration of radiation measurement instruments.

2.4.3 Radioecology and Ecotoxicology Laboratory (ERL)

The Radioecology and Ecotoxicology Laboratory (ERL) [14], formerly named Experimental Radioecology Laboratory (ERL) is located at Cadarache, in the south of France.
ERL missions include:

- To identify, quantify and understand radionuclide transport and transfer mechanisms and the effects of sand in continental aquatic and terrestrial ecosystems by means of experiments performed in controlled environments;
- To establish the main physical, chemical and biological parameters that control the behavior of radio nuclides in the environment;
- To acquire basic data and concepts with the aim of developing phenomenological models and enhancing understanding of observations *in situ*.

ERL's research and development activities are organized around three closely linked main themes:

- Theme 1: The biogeochemical behavior of radionuclides in the "reservoir" compartments of ecosystems – soils and sediments.
- Theme 2: Bioavailability of radionuclides and biological impact: terrestrial aquatic vegetable models.
- Theme 3: Bioavailability and biological impact: animal models and consideration of the trophic relationship.

Experimental Facilities

ERL possesses several facilities (including two radioactive installations on the environmental protection list (ICPE)) for contaminating simplified terrestrial and continental aquatic ecosystems with radionuclides. ERL is equipped with:

- An external irradiation facility, in order to expose small sized organisms (ex. daphnies) or cellular cultures to dose rates of 1 to 1000 mGy/day.
- A hydrobiology hall used for handling and managing large volumes of contaminated water (up to 1 m^3)
- Three laboratories in a controlled area for experiments on emitter radionuclides, such as 239Pu, 240Pu, 241Am, 237Np, etc.

Analytical Resources

ERL resources in the metrology field can be divided into five major categories:

- alpha beta and gamma spectrometry radionuclide measurement techniques;
- histological section preparation techniques (cryostat for photon microscope observation, sections for electron microscopy);
- techniques for radionuclide micro localization in biological tissue (autoradiography and X-ray probe coupled with a transmission electron microscope currently being acquired);
- miscellaneous biochemical dosage techniques (quantification of methallothionines, separation of cytosolic proteins by low pressure chromatography, by HPLC, etc.).

3 PRELIMINARY COMMENTS ON THE SELECTION OF INTERNATIONAL AND NATIONAL CASES TO BE STUDIED

From bibliographic studies, in different sources, several radioecology raboratories were identified and, among them, those presented in Table 1 were selected for this research approach. Nowadays, contacts with the responsible personnel of these laboratories have been made, so that their agreement to participate in this research, and then, in the application of a research instrument, under development, may be obtained.

Table 1: List of Selected Laboratories

Laboratory	Country
Autoridad Regulatoria Nuclear (ARN)	Argentina
Laboratório Radioecológico do Centro Experimental de ARAMAR (LARE)	Brazil
Centro de Química e Meio Ambiente (CQMA-IPEN)	
Laboratório Nacional de Metrologia das Radiações Ionizantes (LNMRI-IRD)	
Laboratório de Radioecologia e Mudanças Globais (LARAMG -UERJ)	
Laboratório de Radioecologia (LAPOC)	
Laboratório de Radioecologia do IF-UFF (LARA)	
Laboratórios de Dosimetria (CDTN)	
Central Laboratory of General Ecology (CLGE)	Bulgaria
Canadian Irradiation Center, Universitu Quc	Canada
Laboratorie de Radioécologie et Écotoxicologie (LRE-IRSN)	France
Laboratoire indépendant d´analyse de la radioactivité (ACRO)	
Laboratoire d'Essais Site et Environnement (LESE)	
Laboratoire radioactivité (CARSO-LSEHL)	
Laboratoire d'Analyses Environnementales (ALGADE-LAE)	
Laboratoire CENTRACO	
Laboratoire d'environnement (EDF-CNPE)	
Laboratoire de Controle Radiotoxicologique - Secteur Environnement (SPRA)	
Laboratoire de Creys-Malville	
Laboratoire de L'entite Evaluation du Secteur Prevention et Radioprotection - Echelon Faible Activit (COGEMA)	
Laboratoire de Mesures et d'Analyses Radiologiques (LMAR)	
Laboratoire de Radioactivite de l'Environnement (EUROFINS)	
Laboratoire de Surveillance de l'Environnement de la direction Sécurité Qualité d'EURODIF production	
Laboratoire Chimie - Environnement	
Laboratoire Environnement Contrôle (LEC) Meury-Sur-Loire	
Laboratoire Environnement du CNPE de Penly	
Laboratoire Environnement du ste du CNPE de Chooz	
Laboratoire (LMSE)	
Laboratoire Metaux Radioactivite	
Laboratoire de Radioanalyse et de Chimie de l'Environnement (LRCE)	
Métrologie et Analyse des Rayonnements Ionisants (SERAC)	
Laboratoire Des Pyrenees - Radioactivite DANS L'environnement	
Section Analyses (AREVA NC – SEPA)	
Service de Radioanalyses-Chimie-Environnement Implanté À Bruyères Le Châtel	
LABoratoire RADiologique envirOnnement et expeRtises (LABRADOR)	France
Radioecology Laboratory of Parma University	Italy
International Atomic Energy Agency (IAEA) - Marine Environment Laboratories Monaco (MEL)	Monaco
The Norwegian Radiation Protection Authority	Norway
Lawrence Berkeley National Laboratory	USA
Los Alamos National Laboratory (LANL)	

4 CONCLUSIONS

The radioecological laboratories have played an important and essential role in environmental preservation actions, demonstrating, also, the relevance given to this issue by the nuclear energy industry. On the other hand, the importance of offering products and services with quality, produced under conditions that do not cause any impact to the environment or the safety and health of workers and collaborators is, today, considered a major condition for the organizations survival and the public acceptance of their activities.

The implementation of an Integrated Management System (Quality, Environment, Work Safety and Health) will enable radioecological laboratories to rationalize costs with internal audit, certification and implementation process, reducing the level of systems complexity and improving their image to the public opinion and the market.

ACKNOWLEDGMENTS

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