Technical Report

Training Workshop on
Quality Assurance for Nuclear Spectrometry

IAEA Headquarters,
Vienna, Austria, VIC M0E27
19 – 23 June 2017

Contents

1. Introduction. 1

2. Current trends and challeges in establishing QA/QC programs in nuclear spectrometry laboratories. 2

3. Benefits and impacts of QA on improvement of reliability of nuclear spectrometry measurements. 6

4. Problems in implementation of QA. 7

5. Importance of certification and accreditation. 7

6. Role of the IAEA in promotion and establishing QA in nuclear spectrometry laboratories in Member States. 8

7. Conclusions. 9

8. Recommendations to the IAEA. 10

Annexes

Annex 1. Agenda 11

Annex 2. List of participants 15

1. Introduction

Nuclear spectroscopy measurements are increasingly applied as the basis of important decisions which are required for setting up national and international regulations in such fields as trade, law, medicine, environmental pollution monitoring, etc. For example, the commercial value of traded products depends critically on the analytical measurements which determine the degree of quality. This requires trust in the measurement results on the international level that can be achieved through introduction of uniform criteria.

Quality Assurance in analytical work, mainly at nuclear spectrometry laboratories, may seem redundant as the majority of laboratories are convinced to perform their work with the utmost care and they have implemented some quality control measures giving them confidence that the obtained measurement results are correct. However, from time to time some doubt may arise when comparing their results with those from other laboratories or when they get biased results in inter-comparison exercises or proficiency tests. In such cases the analyst has to struggle hard to keep confidence in his own work and trust in his analytical technique. In addition, this process leads to the re-analysis of samples, implying this additional time and effort, and the fact that precious samples might be lost. Also, if the analysis is performed for a customer, this can seriously damage the reputation of the laboratory. In order to minimize such incidents Quality Assurance and Quality Control (QA/QC) concepts have been developed to assist the laboratory personnel to achieve a higher degree of transparency of procedures, minimize potential sources of error, standardize the handling of samples, instruments and data, and in the end, decrease the rate of non-conformance results.

The credibility of a laboratory, which should be one of the major concerns of any laboratory management, is increasingly dependent on the documented evidence of QA/QC implementation according to international standards. The more customers request these conditions and the more contracts are relying on its demonstrated evidence, the more laboratories will be convinced that, in order to compete, appropriate QA/QC implementation is indispensable for the survival of a laboratory in the long run. The strong support of Laboratory Managers for a comprehensive effort in this direction is mandatory to cope with the requirements of setting up a complete Quality Management System (QMS) in a particular area of an analytical laboratory.

QA/QC actions are indispensable for ascertaining the quality of results. However, they do not provide objective evidence on the trustworthiness. This can be accomplished by accreditation of the management systems associated to QA/QC for compliance with international standards (such as the ISO/IEC 17025). It should be noted that this is not a mandatory act, and strongly depends on other strategic considerations, e.g., if laboratories get active in serving third parties with results of measurements. While these requirements provide a challenge to developed countries, for developing countries they can be an even greater challenge.

Through the years, the IAEA has supported the laboratories in Member States (MSs) in improving analytical performance and quality of the analytical results. This support has

been provided under the IAEA regular budget projects and a number of regional and national Technical Cooperation projects. Most efforts in this field have been focused on implementation of proper QA/QC practices in analytical laboratories. As a result, some laboratories have established QMSs following relevant international quality standards (e.g., ISO/IEC 17025) and have received accreditation from the relevant national authorities.

Particularly the Nuclear Science and Instrumentation Laboratory (NSIL, formerly NSAL and Instrumentation Unit) has played a leading role worldwide in the effective use of nuclear instrumentation and nuclear spectrometry techniques over the last 20 years. NSIL has extensive experience in providing training and recommendations for Quality Management and Quality Assurance to laboratories implementing nuclear spectrometry techniques. In this regard, two relevant training materials (IAEA-TCS-33/CD and IAEA-TCS-53/CD) have been published in the IAEA Training Course (CD-ROM) series to provide recommendations to laboratories working towards implementing Quality Management Systems and seeking formal accreditation.

As part of the continuity of the IAEA's efforts to improve QA/QC in analytical laboratories of MSs, this training workshop was aimed to highlight, review and discuss issues related to the implementation of QA/QC for proper performing of nuclear spectrometry techniques in Member States (MSs), including addressing recommendations for compliance to ISO/IEC 17025 technical requirements for x-ray emission and gamma-ray spectroscopy methods. Important aspects like method validation, uncertainty calculation and internal and external quality control activities were covered during the workshop. There were also analyzed the current needs of IAEA MSs in this regard.

The IAEA Scientific Officer for this Workshop was Mr. Roman Padilla, NSIL, NAPC. The Chairman of the Workshop was Mr Peter Bode (NUQAM, The Netherlands) and as rapporteurs worked Mr. Jorge Carrazana (CPHR, Cuba) and Ms Mirjiana Cujic (VINCA, Serbia).

2. Current trends and challenges in establishing QA/QC programs in nuclear spectrometry laboratories.

From the relevant information gathered from the participant's presentations and discussions, the current trends and challenges in establishing QA/QC programs in nuclear spectrometry laboratories were identified. The following aspects, grouped in this report by common topics, were raised:

2.1. Implementation of QA/QC in nuclear spectrometry laboratories

- In most cases some quality control measures are already implemented in nuclear spectrometry laboratories of MSs. In this sense, some reference materials (RMs) are available, and the measurement results are recorded and reported. However, the application of QC measures, the use of RMs, the validation of methods, etc,

are mainly done on a basis of personal decision and initiative and are executed in different ways and at different levels even within the same group.

- The level of and approaches in QA/QC implementation varies from country to country. Regarding to this, there is, to some extent, a need to consider harmonized guidelines for QA/QC practices as examples to laboratories for supporting the process leading to accreditation.

- The most effective way to make the laboratory processes more transparent, to incorporate mechanisms for better tracking of laboratory activities, necessary improvements, corrective and preventive actions, is to stick to an international quality standard (e.g. ISO/IEC17025).

- Accreditation of management systems is never a mandatory issue, but QA/QC is indispensable, irrespective if tests are done for internal use or for serving third parties. Accreditation for compliance with the ISO/IEC 17025 may become a pre-requisite for nuclear spectroscopy laboratories if the laboratories provide test results for decision making, such as environmental monitoring and global trade, among other.

- There is a need for sensitization of the laboratory executive management to ensure commitment (top-down) and resources for the implementation of QA/QC practices and the necessary steps towards accreditation.

- A QA/QC system, if properly presented to the stack holders or sponsors of a laboratory can be decisive for the survival of the laboratory. On the contrary, it can be neglected if proper awareness of the benefits of such a system is not yet developed.

- It was pointed out that the implementation of a QMS is a challenge and it has to be done by activities or analytical assays (not using the umbrella approach).

- In the implementation of QA/QC, the great importance of potential human errors, and particularly the technical errors, was analyzed.

- It was emphasized that the internal audit is the most effective tool to identify departures from the QMS, and it is essential for the continual improvement.

2.2. Metrological aspects

- It was noted that the use of the Bottom-up approach (GUM) for uncertainty calculation, although used by the majority of nuclear spectrometry laboratories, is not mandatory. It is also possible to use the Top-down approach. The Top-down and Bottom-up approaches for uncertainty calculation were compared, highlighting the advantages and disadvantages of each one.

- The concept of intermediate repeatability and its link to uncertainty was treated. The Kragten spreadsheet constitutes an alternative for uncertainty calculation used by several nuclear spectrometry laboratories. However, it was mentioned that this approach has to be applied with caution and just in cases when relative uncertainties are small.

- Information was given on how to deal with type B uncertainties and its marked influence in measurement result depending on the counting statistics, background, calibration, and other sources contributing to uncertainty.

- Many of the concepts on method validation and the associate performance indicators are to some extent known within the nuclear spectrometry laboratories. However, typically only laboratories that follow the ISO/IEC 17025 have brought this to the practice; others face various difficulties such as lack of appropriate reference sources of reference materials.

- Regarding detection limits, it was established the importance of linking it with the mass (or volume) of the sample analyzed. Detection limits can also be expressed in absolute units in order to avoid this consideration. It was expressed that there is a new IAEA publication on Interpretation of Characteristics Limits in Radioactive Measurements.

- It was recognized the insufficiency of addressing examples on uncertainty calculation and determination of characteristics limits, in international standards and guides for QM/QA.

- It was emphasized that Certified Reference Materials (CRMs) produced by the IAEA can be used for QC and not for calibration purposes.

- RMs can be used even after the expiration date for certain types of QC in nuclear spectrometry laboratories.

- The samples from proficiency test or inter-comparison exercises should be analyzed as in routine measurements, without doing additional efforts and without taking special precautions.

- It was recognized that in situ measurements have not yet reached a satisfactory level of implementation of QA/QC practices. In this sense, field measurements may need to get adequate attention with respect to QA/QC and analytical quality (trueness, uncertainty, representativeness of the measured object) for the interpretation of the results in support of decisions.

2.3. Proficiency testing and intercomparisons

- Proficiency testing schemes of the IAEA contribute significantly to the improvement of the quality of the results of participating laboratories. Some of them expressed their interest on the availability of certain types of RMs for validation purposes (such as water samples for gross alpha/beta).

- It was identified that there are still nuclear spectrometry laboratories that do not know how to get involved in inter-comparison exercises and proficiency tests organized by the IAEA.

- Several participants reported that often problems arise in receiving the samples from proficiency test or inter-comparison exercises due to custom regulations and problems with delivery services. This fact can seriously affect specially the measurement of short lived radionuclide in ALMERA samples for emergency response.

- Proficiency tests and inter-comparison exercises are not the only way to ensure the reliability of measurement results obtained by nuclear spectrometry laboratories. The establishment of a proper QC, carried out on a daily basis, is the best way to assure this.

- Information was given on the organization and evaluation of IAEA proficiency tests provided for X-ray spectrometry. Some participants expressed their interest for the creation of a network (similar to ALMERA) for XRS. It was informed that the IAEA can not initiate by itself the creation of a network because it has to be based on requests from MSs.

- Of particular interest for the participants was the information given on the foreseen accreditation of the IAEA Environment Laboratories in Seibersdorf for the production of CRMs (at the beginning for certain types of matrices and radionuclides) and for the provision of inter-comparison exercises and proficiency tests.

2.4. Education, training and sustainability

- A culture of thinking as a common attitude to carry on QA/QC in a systematic way needs to be developed and supported by all personnel involved, from the laboratory technician, the laboratory head, to the laboratory management and director of the organization.

- There is still the need for explanation and assistance for practical application of the ISO/IEC 17025 recommendations (including the new version) to the individual nuclear spectrometry techniques to facilitate the implementation of internationally accepted quality principles and to promote the attempts in MSs Laboratories to obtain accreditation.

- Education in the principles and practices of QA/QC was identified as one of the important issues for its successful implementation and sustainability. The usefulness of e-learning tools on implementation of QMSs was recognized by the participants and the IAEA. In this sense, it was expressed the necessity of updating the existing e-learning tools, or producing new ones in other fields of interest, according to the new guides and standards.

- The necessity for assuring the sustainability of metrological competence in MSs nuclear spectroscopy laboratories was identified, given the retirement or mobility of the personnel. In this sense, the laboratory's continuity with respect to expertise, know-how and standard should be made independent of its personnel as far as possible. As part of a QA/QC system the existence of written procedures assures some level of continuity even when personal experience is lost due to shift or exchange of personnel.

3. Benefits and impacts of QA on improvement of reliability of nuclear spectrometry measurements.

The implementation of QMSs including QA and QC, can lead to the improvement of methods and techniques associated to nuclear spectrometry laboratories, and the identification of large and small problems. Eventually, this enables the laboratory to implement preventive and corrective actions.

Increased efficiency and effectiveness, a lower rate of susceptible measurements and higher grade of transparency of procedures will increase the confidence and reliability of the results. This will lead to enhanced productivity and improved reputation of the laboratory.

The reputation of any laboratory clearly relies on both the quality of the results as well as the agreed delivery time of analytical measurements. In this sense, the implementation of a QMS might lead to a significant increase in the number of customers, resulting in extended research and financial gains.

The implementation of QMSs also allows the effective teaching and training of new staff and students, and the establishment of a culture to follow rigorous QA and QC procedures. It also helps in preservation of knowledge.

Particularly, the accreditation of a laboratory has impacts beyond improved QA and QC procedures. A reputable accredited laboratory can provide its services to a wide range of regulatory institutions which may have significant impact in the social and economic domains. Accreditation contributes to the sustainability of the quality assurance system as well.

4. Problems in implementation of QA.

Implementation of QMSs is, in many facilities, hampered by:

- insufficient staff trained in quality management,
- insufficient management commitment to provide the necessary minimum resources such as a budget for running costs of the laboratory (e.g., for procurement of standards and consumables, equipment and even personnel) and for accreditation fees especially in countries without national accreditation bodies,
- insufficient insight in metrological requirements,
- insufficient knowledge on how to interpret the requirements to practical implementation,
- insufficient national training opportunities on QA/QC in many MSs,
- national laws and regulations,
- Insufficient support by executive management.

5. Importance of certification and accreditation.

Certification and accreditation of nuclear spectrometry laboratories have the following intrinsic benefits:

- there is a permanent motivation to improve quality,
- there might be an increase in the number of customers,
- the credibility on the analytical results emitted by the laboratory is higher, and trust is increased,
- better discipline to follow the written rules and procedures,
- Provision of strong arguments to negotiate with management.

6. Role of the IAEA in promotion and establishing QA in nuclear spectrometry laboratories in Member States.

- To continue the support for the implementation of QMSs in nuclear spectrometry laboratories of MSs.

- Provision of training in the field of quality management for nuclear spectrometry laboratories.

- To provide technical expertise and support in metrological competence for the implementation of QMSs and accreditation.
- To continue organizing PTs and inter-comparison exercises with samples with traceable metrological property values.

- To expand the availability of reference materials in different matrices, as those required for some participants for validation purposes (such as water samples for gross alpha/beta).

- Provide training for auditors from the accreditation boards in MSs, and trainers on implementation of QA/QC in nuclear spectrometry techniques to better understand those techniques and its quality components (technical requirements, uncertainty, characteristics limits, etc)

- Organization of technical meetings, workshops and seminars in QA/QC issues for MSs.

- To promote the cooperation between laboratories in MSs and creation of a network of qualified expert auditors in radioactivity measurements to assist accreditation bodies of MSs.

- Reinforce the support for TC projects dedicated to QA/QC.

- Based on the requests from Member States, to support the creation of a network (similar to ALMERA) for XRS laboratories.

- Elaboration of QA/QC guides and documents for in-situ applications.

7. Conclusions

Participants agreed that the objectives of this Training Workshop were met:

- The information provided during the workshop will contribute to improve their procedures for QA/QC.
- The presentations in the workshop on the concepts of method validation and uncertainty of measurement, as applied to radiation measurement techniques, have filled the gap of insufficient addressing examples from these techniques in international standards and guides for QA/QC.
- The proficiency testing exercises and inter-comparisons coordinated by the IAEA are very important services to its Member States for an independent and impartial assessment of the degree of accuracy of the measurement results, and contribute to the identification of unforeseen sources of error in the laboratory's operational procedures.
- Quality Management Systems are an important asset for laboratories providing measurement services to external stakeholders. Accreditation of such systems for compliance with international standards is, however, often unviable due to lack of resources and in some cases the absence of national accreditation bodies.
- The revision and update of international standards such as the ISO/IEC 17025, will require a continuous support to radiation national laboratories with respect to the interpretation and implementation.

8. Recommendations to the IAEA

- To continue the provision of proficiency testing schemes for nuclear spectrometry laboratories.
- To continue the production of reference materials for QC and method validation in radiation / trace elements / stable isotopes measurement laboratories.
- To consider the elaboration of a guidance document on method validation with examples of application in radiation measurement. It would be appropriate if such a document also includes reference to, and examples of metrological terms and concepts.
- To consider the publication of a technical document addressing recommendations for Type A / Type B uncertainty estimation, as a follow up for topics not sufficiently covered in the previously published IAEA TECDOC 1401.
- To provide training courses for nuclear spectrometry laboratories on metrological topics and on interpretation of the requirements of international standards – such as the ISO/IEC 17025- towards practical implementation. As a new edition of the

international standard ISO/IEC 17025 will be issued (ISO/IEC 17025:2017), explanation of and training in the new/additional requirements of this new version may be urgently needed.

- To continue supporting nuclear spectrometry laboratories focused on accreditation by provision of technical experts addressing advices for accreditation audit teams.
- To foster the presentation of concepts and the development of technical cooperation projects on implementing Quality Management Systems in nuclear spectrometry laboratories in developing Member States, including regional projects.
- Similar to the existing ALMERA network, to create and organize activities in support of technique-specific networks, such as XRS, IBA, among other examples.

Annex 1. Agenda of the Training Workshop

Training Workshop on
Quality Assurance for Nuclear Spectrometry

IAEA Headquarters,

Vienna, Austria, VIC M0E27

19 – 23 June 2017

Ref. No. F1-TR-52968

WORKSHOP AGENDA

Monday 19		
08:30 – 09:00	Registration	
09:00 – 09:15	Official Opening:	Ms Meera Venkatesh, Director, Division of Physical and Chemical Sciences, IAEA
09:15 – 09:30	Organizational arrangements Presentation of the Workshop Agenda, Election of Chairperson and Rapporteurs	Mr Roman Padilla Alvarez Nuclear Science and Instrumentation Laboratory (NSIL), NAPC, IAEA
09:30 – 10:00	Brief introduction of the participants	All participants
10:00 – 10:30	*Coffee Break*	
	Session 1: The Quality Management activities in the IAEA Laboratories using nuclear spectrometry techniques	
10:30 – 11:00	The IAEA Quality Policy and Objectives in the Department of Nuclear Sciences and Applications. Past and current activities	Mr Ales Fajgelj, Quality Systems Manager, IAEA-NA
11:00 – 11:45	The IAEA Environmental Laboratories: Mission and Quality Management activities	Mr Manfred Groening IAEA Terrestrial Environment Laboratory (TEL) Ms Martina Rozmaric IAEA Radiometrics Marine Laboratory (RML)
11:45 – 12:15	The Nuclear Science and Instrumentation Laboratory: Mission	Mr Roman Padilla Alvarez, IAEA NSIL

	and Quality Management activities	
12:15 – 14:00	*Lunch break*	
	Session 2: Towards compliance to ISO 17025 requirements in method validation	
14:00 – 14:45	Use of correction actions in Management of Human Errors in Analytical Laboratories	Mr Ales Fajgelj, Quality Systems Manager, IAEA-NA
14:45 – 15:30	ISO 17025:2005 Standard requirements	Ales Fajgelj, Quality Systems Manager, IAEA-NA
15:30 – 16:00	*Coffee Break*	
16:00 – 16:45	Uncertainty and detection limits in gamma ray spectrometry	Mr Jorge Carrazana CPHR, Cuba
16:45 – 17:30	Uncertainty estimation in nuclear analytic techniques: The advantages of Type B evaluation in radiation measurement techniques	Mr Peter Bode Delft University of Technology, The Netherlands
Tuesday 20		
	Session 2: Towards compliance to ISO 17025 requirements in method validation (continued)	
09:00 – 09:45	Specifics of x-ray emission techniques in method validation	Mr Roman Padilla Alvarez IAEA, NSIL
09:45 – 10:30	Validation of laboratory and in-situ gamma spectrometry measurements	Mr Alexander Mauring IAEA, TEL
10:30 – 10:45	*Coffee Break*	
10:45 – 11:30	Validation of ICP-MS trace element analysis	Ms Monika Horsky, IAEA, TEL
11:30 – 12:15	Validation of alpha spectrometry analysis	Mr Bojan Seslak, IAEA, TEL Ms Martina Rozmaric IAEA Radiometrics Marine Laboratory (RML)
12:15 – 13:45	*Lunch Break*	
13:45 – 14:30	Specifics of validation of SEM-EDS analysis	Mr Ernesto Chinea Cano, Environmental samples Laboratory, Office of Safeguards analytical services
14:30 – 15:15	The constraints related to the implementation of quality management	Mr Edouard Nzambimana, Burundi Bureau of Standards

	system for laboratory accreditation in developing countries	and Quality Control
15:15 – 15:30	*Coffee Break*	
15:45 – 17:00	Round Table: Main difficulties faced in IAEA MSs laboratories for Quality Management / Quality Assurance	
Wednesday 21		
	Session 3: Quality control of analytical results	
09:00 – 09:45	Main actions in support of internal/external quality control	Ms Denis Glavič Cindro, Institute Josef Stefan, Slovenia
09:45 – 10:30	The IAEA reference materials and fitness for quality control	Mr Sandor Tarjan, IAEA-TEL
10:30 – 10:45	*Coffee Break*	
10:45 – 11:15	The IAEA Proficiency Tests for XRF laboratories: recent developments and updates	Mr Roman Padilla Alvarez, IAEA-NSIL
11:15 – 12:00	The ALMERA proficiency tests: achievements and challenges	Mr Alexander Trinkl, IAEA-TEL
12:00 – 13:30	*Lunch Break*	
13:30 – 16:00	Visit to IAEA laboratories in Seibersdorf: TEL and NSIL	
19:30 -	*Social event*	
Thursday 22	***Session 4: Examples of QM/QA in IAEA Member States laboratories***	
09:00 – 10:30	*Accreditation of TXRF analysis of surface contamination in wafers*	*Mr Peter Kregsamer Atominstitut, Austria*
10:30 – 10:45	*Coffee Break*	
10:45 – 11:30	*Evaluation of uncertainty components associated with alpha-particle spectrometric measurements of uranium isotopes in water*	*Mr Abdullah Dirican Turkish Atomic Energy Authority, Turkey*
11:30 – 12:15	*Quality Assurance within Gamma Spectrometry Laboratory of CNESTEN*	*Mr Khalis Laraki CNESTEN, Morocco*
12:15 – 13:45	*Lunch Break*	
13:45 – 14:30	*Validation of APM analysis by PIXE*	*Ms Ivana Zamboni, Ruder Boskovic Institute, Croatia*
14:30 – 15:15	*Validation of APM analysis by EDXRF and TXRF*	*Mr Janos Osan IAEA NSIL Consultant*
15:15 – 15:30	*Coffee Break*	

15:30 – 16:15	*Quality Control and Validation of Gamma and Alpha Spectrometric Techniques for NORM Measurements*	*Mr David Okho Kpeglo* *Ghana Atomic Energy Comission*
16:15 – 17:00	*Quality Control and Assurance of Neutron Activation Analysis*	*Mr Peter Bode* *Delft University of Technology, The Netherlands*
Friday 23	***Session 5: Drafting of Workshop report***	
9:00 – 9:30	Approval of Report structure and setting working groups	
9:30 – 12:30	Drafting report sections	
12:30 – 13:00	Closing remarks	

Annex 2. List of participants

Country	Salutation	Nominee	Institution	email
Bolivia	Ms	Leslie Fanola Guarachi	IBTEN	lfanola@ibten.gob.bo
Cuba	Mr	Jorge Antonio CARRAZANA GONZÁLEZ	CPHR	carrazana@cphr.edu.cu
Mexico	Ms	Geyser Fernandez Cta	Instituto de Geología, UNAM	geyserfc@geologia.unam.mx
El Salvador	Mr	Julio Payes	Universidad de El Salvador	julio.payes@ues.edu.sv
Brazil	Ms	Renata FREIRES DE SOUZA CARDOSO	ELECTROBRAS Electronuclear S.A.	rfsouza@eletronuclar.gov.br
Austria	Mr	Peter Kregsamer	Atominstitut	pkregsam@ati.ac.at
Croatia	Mr	Ivana Zamboni	Institute Ruder Boskovic	ivana.zamboni@irb.hr
Serbia	Ms	Mirjiana Cujic	Institute of Nuclear Sciences VINCA	cujicm@vinca.rs
Slovenia	Ms	Denis GLAVIC-SINDRO	Institute Josef Stefan	denis.cindro@ijs.si
The Netherlands	Mr	Peter Bode	NUQAM Consultancy	peter.bode@ymail.com
Turkey	Mr	Abdullah Dirican	Saraykov Nuclear Research and Training Centre	abdullah.dirican@taek.gov.tr
Greece	Ms	Maria Nikolaki	Greek Atomic Energy Commission	maria.nikolaki@eeae.gr
Syrian Arab Republic	Mr	Mohammad Ameer	Atomic Energy Commission of Syria	ameerm_86@yahoo.com
Bangladesh	Mr	Rahman Md Safiur	Atmospheric and Environmental Chemistry Lab, Atomic Energy Centre	safiur_baec@yahoo.com
India	Mr	Rahul Tripathi	Radiochemistry Division, Babha AC	rahult@barc.gov.in
Burundi	Mr	Edouard Nzambimana	Burundi Bureau of Standards and	alinzamed@yahoo.fr

			Quality Control	
Kenya	Mr	Angeyo Hudson Kalambuka	University of Nairobi	hkalambuka@uonbi.ac.ke
Sudan	Mr	Salim Ekrami	Chemistry and Nuclear Physics Institute	ekrami86@gmail.com
Congo Democratic Republic	Mr	Christian Poloto Ilunga	Atomic Energy Commission	christian_poloyo@yahoo.fr
Ethiopia	Mr	Eshetu Zege	Ethiopian Radiation Protection Authority	etat2323@yahoo.com
Egypt	Ms	Hanan Diab	Nuclear and Radiological Regulatory Authority	hnndiab@yahoo.co.uk
Morocco	Mr	Khalid Laraki	CNESTEN	laraki@cnesten.org.ma
Ghana	Mr	David Okho Kpeglo	Radiation Protection Centre, Ghana Atomic Energy Commission	kpeglokkd@yahoo.com
Nigeria	Mr	Oghogho Peter Onyagbodor	Centre for Marine Pollution Monitoring and Seafood Safety, (CMPMSS), University of Port Harcourt	peter.onyagbodor@uniport.edu.ng
Madagascar	Mr	Naivo Rabesiranana	Institut National des Sciences et Techniques Nucléaires (INSTN)	rabesiranana@yahoo.fr