Session A, Track 1:
Monitoring, Measurement, and Modeling I

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10:45 a.m. - 12:35 p.m.

Chair: Gregg Dempsey, United States Environmental Protection Agency

Workshop Summary: Rapid Radioactivity Measurements in Routine and Emergency Situations

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ABSTRACT

While Europe is fascinated with the prospect of a rapid response to another Chernobyl-type incident, North America is more focused on rapid radioassay methods for environmental remediation and South America is concerned with the rapid determination of natural radionuclides. The UK, along with many of the other European countries, has an accident response plan. Planning for accident response will include three phases: a) <24 hour using a preestablished early warning survey system; b) about 24 hours to assure appropriate decision making for the quarantine of foods and water; and c) >24 hours for long-term implications. Under an accident scenario, logistics will be very important to assure appropriate distribution of samples, sufficient supplies for radiochemical analyses, data collation and interpretation. Regardless of the underlying reasons for needing rapid radioassay methods, it was generally felt by the Conference participants that the basic measurement tools were generally available. The natural growth of science will, of course, continue to evolve toward more rapid, simpler, less expensive and less polluting radioassay methods.

INTRODUCTION

Over the past decade, rapid radioanalyses have been called upon to provide initial evaluations of emergency incidence, and for ongoing assessments for environmental remediation and decontamination and decommissioning programs It is timely to reflect on the current state-of-the-art and chart a course for a rational development of new investments in methods and instruments to meet future needs. The Conference on Rapid Radioactivity Measurements in Emergency & Routine Situations was held at the National Physical Laboratory (UK), co-sponsored by the International Atomic Energy Agency, International Committee on Radionuclide Metrology, and the Royal Society of Chemistry - Radiochemical Methods Group, to. a) define the state-of-the-art; b) document the results of the presentations and discussions, and c) develop recommendations on what should be improved and developed, the rational for these recommendations, and determine priorities (based on purpose, drivers, requirements) The conference was attended by representatives from Austria, Canada, Croatia, Czech Republic, Finland, France, Italy, Japan, The Netherlands, Norway, Republic of China, Russia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, and the United States of America. Conference proceedings will be published by Fall '98, and selected papers will be published in

Radiochemistry and Radioactivity at the same time. Measurement issues included in the papers and posters presented are listed in Table 1.

DISCUSSION

Programmatic Issues

Emergency response is a high visibility issue in Europe because of Chernobyl. The major objectives for rapid radioanalyses are to identify and quantify the radionuclides present in order to assess the source term and potential doses to the most sensitive populations. Since the impact to food and environment must be accessed quickly, less accuracy can be tolerated, and the cost of the analysis is generally not an issue. In the EU, the regulatory limit for radioactive contamination in food is <1 kBq per kg.

Since 1987, the IAEA responded to requests by member states to help set up laboratories with rapid methods to monitor food supplies and the environment by providing a six-year Fellowship Training program to improve the accuracy of measurements and teach the principles of the measurement techniques. The participants, however, had varying agenda, depending of their site of origin (Emergency Response was the chief focus of EU participants, Remediation was the focus of those from South America, and decontamination and decommission (D&D) was the focus of those from North America).

Table 1. Conference Issues

Monitoring Programs	Survey Modes	Analytes	Matrices	Radiochemistry	Detectors and Instruments
France	Aircraft	Actinides	Air Filters	Sample Dissolution	Calibrations
Spain	Sea Floor	Activation Products (^{60}Co)	In-situ	Preconcentration	γ-Spectroscopy
UK	Vehicle	Gamma Scan	Bioassay	Bioavailability	ICP-MS
		Gross Alpha/Beta	Nuclear Waste	Column Extraction	Liquid Scintillation
			Soil		
		Fission Products (^{3}H, ^{14}C, Noble Gases, ^{90}Sr, ^{134}Cs, ^{137}Cs)		Ion Chromatography	Mobile Systems
			Swipes		Monte Carlo
		Natural Nuclides (Rn)	Urine	Method Validation	
			Water		SIMS

In the UK, LARMACC and RADMIL exemplify the local authority monitoring effort, while RIMNET is supported by the national Department of Environment, Transport and Regions (DETR) for international incidents. Each nuclear establishment and authority has the responsibility to have an emergency plan for preparedness that includes: a) radioanalytical laboratories, b) means to handle data flux, c) sample distribution, d) data methodology and evaluation, and e) means for interpretation of the data for the authorities. RIMNET consists of ninety-two automatic gamma ray sensitive Geiger-Müller detectors with associated data collectors throughout the UK which are accredited by external bodies, intercompared on a regular basis, and maintained on a regular basis. Resulting data are released into the public domain by the DETR.

The UK universities may contribute to the LARMACC/RADMIL/RIMNET systems but are not generally part of the decision process and are not generally set up for routine analyses. However, some universities, such as Southampton University, have begun to install rapid methods and set up laboratories under contract with local authorities. The rapid measurement requirements are generally not well defined (accuracy and minimum detectable activity, MDA), and will remain so unless a customer driven issue creates investment resources for their development, and for accreditation programs as well. Reporting of analytical results will be by the university investigators rather than a local or national authority.

The UK hospitals (and, indeed, many other laboratories) can input supplementary analytical data into the RIMNET database if approved to do so by DETR. However, it was suggested that these institutions be part of an ongoing intercomparison system to establish their baseline and demonstrate comparability.

It was also suggested that information is released from one central point to avoid confusion and conflicting assessments and statements.

Remediation, D&D and effluent release programs, on the other hand, are more concerned with determining the amount of radiation emitted and radionuclide content for regulatory compliance (surveillance, process control, process assessment, long-term monitoring) to control waste released from plant/site, and for environmental management. These programs are health regulation driven and measurements of minimal cost are desired. Measurement accuracy must be acceptable which is more important than analytical speed. High analytical throughput, however, is desired because of the economic incentive of fast turnaround times, potential for higher profit, ease of training analysts and robustness.

Investment of resources to develop and implement specific analytical methods are strongly influenced by a country's priorities. In South America, the emphasis for radioanalytical methods is primarily dictated by remediation and effluent release of natural radionuclides. North America focuses its radioanalytical methods on measurements on D&D and environmental remediation from nuclear weapon production and nuclear power; Europe has emphasized monitoring effluent release from nuclear reprocessing activities.

Derived Release/Emission Limits are estimated by: a) using the regulated dose limits for all radionuclides through multiple pathways, b) identifying critical exposed groups, c) identifying the most significant critical group per radionuclide, d) reducing the derived release/emission limit by a safety factor (100-1000), e) comparing the measured release to the reduced derived limit, and f) reviewing the procedure and limits periodically since the critical group can change. Population exposures to non-environmental sources are limited to 15-25 mRem per year per person in the U.S., $<$ 1kSv per critical group per year in Canada, and $<$ 0.4 Bq per gram in all matrices in the UK. In some countries, the reduced limits are managed on a per year basis. In other countries, the safety factor is continually increased as experience demonstrates that the increased safety factor is achievable and verified by measurements. When ICRP 60 is invoked, the reduced limits are further constrained because of the possibility of exposure to multiple sources. ICRP 60 recommends a limit of 0.3 mSv total exposure for the critical personnel.

As technology progresses, radioanalytical methods will evolve toward more convenient, faster, and cheaper techniques, and should be able to maintain measurement quality Measurement issues include: a) establish criteria for accuracy and precision, b) performance testing and accreditation programs to establish credibility, c) define required MDLs, d) policy for handling negative numbers, e) statement of uncertainty that is easily understood by customers, and f) investment resources to establish and verify measurement methods

Selected Papers

The conference presentations were outstanding and addressed critical rapid methods issues. A few issues, particularly, should be highlighted to indicate recent progress. The references noted here are to be incorporated in the conference proceedings.

The Italians (De Felice et al. *The Validation of a National Standard for Rapid Measurement of Strontium Isotopes in Milk*) were the first to establish a national standard radiochemical procedure for the determination of ^{89}Sr and ^{90}Sr in milk for emergency situations. The paper describes the validation of the method through an intercomparison exercise, much like that used by the U.S. American Society for Testing and Materials (ASTM). The method was validated to ± 15 percent, and is sufficiently good for emergency situations.

Croudace et al. (*A Highly Efficient Technique for the Determination of Actinides, Particularly Plutonium and Uranium, in Soils Following a Borate Fusion*), Uchida & Tagami (*A Rapid Separation Method for Determination of ^{99}Tc in environmental Waters by ICP-MS*, and Tagami and Uchida (*Use of a Combustion Apparatus for Low-level ^{99}Tc Separation from Soil Samples*) focused on utilizing mass spectrometry-based measurements for long-lived radionuclides such as uranium, thorium, plutonium and technetium. It is anticipated that mass spectrometric measurements will demand the creation of new tracer Standard Reference Materials (SRMs) to meet their measurement needs.

Bojanowski et al. (*Sources of Bias in Rapid Methods for ^{89}Sr and ^{90}Sr Assay in Environmental Samples*), and Warwick & Croudace (*Review of Techniques for the Rapid Identification and Determination of pure β Emitters*) recognized the importance of measuring long-lived pure β-emitting radionuclides. Bojanowski's paper summarized sources of bias for the generally miserable measurement of radiostrontium isotopes. Over a dozen papers focused on the determination of ^{89}Sr and ^{90}Sr. Although there are several very good laboratories in the world that can probably reliably measure ^{90}Sr, there is a need to develop the capability to measure equally well many other pure β-emitter radionuclides.

Radionuclide speciation issues (Beresford et al. *The Comparative Importance of Bioavailability: An Assessment of Rapid Prediction Techniques to Determine the Bioavailability of Important Radionuclides for Transfer to Animal Derived Food Products Following a Contamination Event*) was not a major focus of the Conference because it is generally thought of as a secondary concern. However, this issue will become recognized for its utmost importance in understanding the source term, fundamental influence on strategies to be used for radiochemical measurements, and the effects it will have on a radionuclide's transport through the environment and food web.

Additional flexibility in calibrating gamma-ray spectrometers by computational tools is beginning to augment standards-based instrument calibrations (MacDonald et al. *In-situ γ-ray Spectrometry*, Likar et al. *Monte Carlo Calculations with GEANT for in-situ Measurements*, and Bronson *ISOCS: a Laboratory Quality Ge γ Spectroscopy System That you can Take to the Source for Immediate High Quality Results*). While the national standard laboratories can develop benchmark reference sources, the community requires increasingly diverse calibrations for their project/program-specific needs. The measurement community's research efforts to derive virtual calibrations must invest a focused effort to develop and validate its computational skills with increasingly complex benchmark standards.

CONCLUSION

Radioanalytical issues that need to be carefully addressed include:

- Communications between analysts and clients that include: planning, training, and establishing action levels.
- Screening methods that are important for early decision making.
- Routine measurements that balance turn-around-time, cost and quality. Under emergency situations, however, turn-around-time with as much quality possible overshadows the cost of the analysis.
- Rapid radioassay methods that must be supported by as much verification/validation, traceability, and quality assurance/control as used for routine measurements.

Future research will need to assure that only known amounts of quality is sacrificed while developing more rapid, simpler, less expensive and less polluting radioassay methods. If critical steps in a radiochemical method are to be eliminated, their effect on measurement quality must be quantified. As a result, additional efforts must be invested in the validation and verification of any new method.

Although a critical high-priority call for new research and initiatives will probably not be recommended to the International Atomic Energy Agency or International Committee for Radionuclide Metrology, there will be a need for coordinated development of Reference Materials for intercomparison studies and accreditation programs to validate and verify new and standard protocol radioassay methods and processes. Furthermore, additional effort should be placed on developing SRMs for screening measurements.