Journal of Environmental Radioactivity 115 (2013) 73–82

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Short communication

An invitation to contribute to a strategic research agenda in radioecology

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ARTICLE INFO

Article history:
Received 8 July 2012
Accepted 12 July 2012
Available online 10 August 2012

Keywords:
Radioecology
Research
Agenda
Vision
STAR
ALLIANCE

ABSTRACT

With intentions of integrating a portion of their respective research efforts into a trans-national programme that will enhance radioecology, eight European organisations recently formed the European Radioecology ALLIANCE (www.er-alliance.org). The ALLIANCE is an Association open to other organisations throughout the world with similar interests in promoting radioecology. The ALLIANCE members recognised that their shared radioecological research could be enhanced by efficiently pooling resources among its partner organizations and prioritising group efforts along common themes of mutual interest. A major step in this prioritisation process was to develop a Strategic Research Agenda (SRA). An EC-funded Network of Excellence in Radioecology, called STAR (Strategy for Allied Radioecology), was formed, in part, to develop the SRA. This document is the first published draft of the SRA. The SRA outlines a suggested prioritisation of research topics in radioecology, with the goal of improving research efficiency and more rapidly advancing the science. It responds to the question: "*What topics, if critically addressed over the next 20 years, would significantly advance radioecology*?" The three Scientific Challenges presented within the SRA, with their 15 associated research lines, are a strategic vision of what radioecology can achieve in the future. Meeting these challenges will require a directed effort and collaboration with many organisations the world over. Addressing these challenges is important to the advancement of radioecology and in providing scientific knowledge to decision makers. Although the development of the draft SRA has largely been a European effort, the hope is that it will initiate an open dialogue within the international radioecology community and its stakeholders. This is an abbreviated document with the intention of introducing the SRA and inviting contributions from interested stakeholders. Critique and input for improving the SRA are welcomed *via* a link on the STAR website (www.star-radioecology.org).

1. Introduction

Radioecology is a branch of environmental sciences concerned with radionuclides as contaminants and radiation as a stressor. Radioecological studies form the basis for estimating exposures, doses and the consequences of radioactive pollution in the environment, including risks to humans. The study of environmental radioactivity includes aspects common with other groups of pollutants (i.e., environmental transport, fate, and effects to humans and the environment), as well as aspects specific to radionuclides (i.e., specialised source terms, external irradiation pathway, radiation dosimetry, radioactive decay, and unique aspects of measurement). Radioecological expertise is needed whenever radiation within the environment is of potential concern

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http://dx.doi.org/10.1016/j.jenvrad.2012.07.011

and an evaluation of potential risks is needed. For example, radioecology is important when evaluating the risks from the nuclear fuel cycle, including disposal of nuclear waste; in the debate on effects from chronic, low level exposures; and in response to emergencies that involve nuclear materials, such as nuclear accidents or terrorist events.

To address emerging issues in radioecology within Europe, eight organisations[1] signed a Memorandum of Understanding (MoU) in 2009 that formed the European Radioecology ALLIANCE.[2] The ALLIANCE is an Association open to other organisations throughout the world with similar interests in promoting radioecology. The MoU states the intentions of ALLIANCE members to integrate a portion of their respective research efforts into a trans-national programme that will enhance radioecology. The ALLIANCE members recognise that their shared radioecological research can be strengthened by efficiently pooling resources among its partner organizations and prioritising group efforts along common themes of mutual interest. A major step in this prioritisation process was to develop a Strategic Research Agenda (SRA). An EC-funded Network of Excellence in Radioecology, called STAR (Strategy for Allied Radioecology[3]), was formed to, among other tasks, develop the SRA.

This manuscript is the first journal-published draft of the SRA. It is a suggested prioritisation of research topics in radioecology, with a goal of improving research efficiency and more rapidly advancing the science. The SRA responds to the question: "*What topics, if critically addressed over the next 20 years, would significantly advance radioecology*?"

The SRA's three Scientific Challenges and 15 associated research lines are a strategic vision of what radioecology can achieve in the future through a directed effort and collaboration by many organisations. It is a vision in which the participants were asked to think creatively and without bounds as they imagine the results that could most shape the future of radioecology and benefit stakeholders. The reality is that the SRA will require considerable resources and time to bring to fruition. The "how", "means" and "practicality" of accomplishing the research items presented in the SRA will be developed in a subsequent document that outlines the Roadmap required to achieve the visions. The Roadmap will link the SRA with the evolution of the science by providing the necessary action plans, resource allocation, and milestones required to achieve the SRA. The Roadmap will be in an expanded version of the SRA, planned for January 2014.

Although the development of the SRA has largely been a European effort, the hope is that it will initiate an open dialogue within the international radioecology community. STAR is seeking input from

- the larger radioecology research community;
- industry;
- STAR's External Advisory Board;
- international organisations [e.g., World Health Organization (WHO); United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR); International Commission on Radiological Protection (ICRP), International Atomic Energy Agency (IAEA)];
- the International Union of Radioecology (IUR);
- other pan-European platforms with research topics that require radioecology [Multidisciplinary European Low Dose Initiative (MELODI); European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery (NERIS); Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP)]
- other radioecology networks around the world [e.g., National Center for Radioecology (NCoRE), within the United States]; and
- interested stakeholders.

This is an abbreviated document with the intention of introducing the SRA and inviting contributions from interested stakeholders. Critique and input for improving the SRA are welcomed *via* a link on the STAR website (www.star-radioecology.org).

1.1. How the strategic research agenda developed

The SRA was distilled from the interests of STAR and ALLIANCE member organisations; several evaluations on the state of radioecology, including input from stakeholders (FUTURAE, 2008) and the International Union of Radioecology[4]; as well as lists of research needs, data gaps and recommendations for the future of radioecology, or its allied science of ecotoxicology (Whicker et al., 1999; Hinton, 2000; Brechignac et al., 2003; Calow and Forbes, 2003; Brown et al., 2004; Eggen et al., 2004; Garnier-Laplace et al., 2004; Shaw, 2005; Alexakhin, 2006; OECD-NEA, 2007; Brechignac et al., 2008; Larsson, 2008; Pentreath, 2009; Salbu, 2009; Repussard, 2011; Artigas et al., 2012).

Additionally, the SRA was formulated by considering several aspects related to:

- *Recent changes in policy*: It is now recognised that the radiological sciences should be able to explicitly demonstrate protection of the environment, rather than implied through the protection of humans (IAEA, 2006; ICRP, 2007, 2008). For example, an OECD/NEA report (2007), Scientific Issues and Emerging Challenges for Radiological Protection, specifically states that: "*The current system of radiological protection, not having been designed for this purpose, is a weak tool to demonstrate the level of radiological protection afforded to the environment*".
- *New paradigms and scientific advancements*: Recent changes relevant to radiation effects on humans are also relevant to radioecology, and go beyond the previous dogma of single target theory for cell survival as the only mode of action for cell death. New ideas are being incorporated into the science, such as bystander effects, epigenetics, genomic instability and population consequences from multigenerational exposures. Additionally, the radioecology of the future will need to capitalize on the rapid advances in the proteomic and genomic sciences to help develop mechanistic explanations and early warning biomarkers.
- *Improving credibility with stakeholders*: Uncertainties and lack of predictive power in risk assessments are major contributors to the public's reduced credibility of radiological sciences. Credibility of assessment models is particularly important because their predictions are often key constituents in

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[2] www.er-alliance.org.

[3] www.star-radioecology.org.

[4] www.iur-uir.org/en/.