Science of the Total Environment 470–471 (2014) 660–668

Contents lists available at ScienceDirect

Science of the Total Environment

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

Short Communication

A web-based tool to engage stakeholders in informing research planning for future decisions on emerging materials ☆

Christina M. Powers [a,*], Khara D. Grieger [b,1], Christine Ogilvie Hendren [c,2], Connie A. Meacham [a,3], Gerald Gurevich [a,4], Meredith Gooding Lassiter [a,5], Eric S. Money [b,6], Jennifer M. Lloyd [b,7], Stephen M. Beaulieu [b,8]

[a] National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, USA
[b] RTI International, 3040 Cornwallis Rd., Research Triangle Park, NC 27709, USA
[c] Center for the Environmental Implications of NanoTechnology, Duke University, Durham, NC 27708, USA

HIGHLIGHTS

- A web-based, interactive decision support tool was piloted for emerging materials.
- The tool (CEAWeb) was based on an established approach to prioritize research gaps.
- CEAWeb facilitates multi-stakeholder prioritization of research gaps.
- We provide recommendations for future versions and applications of CEAWeb.

ARTICLE INFO

Article history:
Received 25 July 2013
Received in revised form 13 September 2013
Accepted 3 October 2013
Available online 29 October 2013

Editor: Damia Barcelo

Keywords:
Comprehensive environmental assessment
Engineered nanomaterials
Research planning
Risk assessment
Stakeholder engagement

ABSTRACT

Prioritizing and assessing risks associated with chemicals, industrial materials, or emerging technologies is a complex problem that benefits from the involvement of multiple stakeholder groups. For example, in the case of engineered nanomaterials (ENMs), scientific uncertainties exist that hamper environmental, health, and safety (EHS) assessments. Therefore, alternative approaches to standard EHS assessment methods have gained increased attention. The objective of this paper is to describe the application of a web-based, interactive decision support tool developed by the U.S. Environmental Protection Agency (U.S. EPA) in a pilot study on ENMs. The piloted tool implements U.S. EPA's comprehensive environmental assessment (CEA) approach to prioritize research gaps. When pursued, such research priorities can result in data that subsequently improve the scientific robustness of risk assessments and inform future risk management decisions. Pilot results suggest that the tool was useful in facilitating multi-stakeholder prioritization of research gaps. Results also provide potential improvements for subsequent applications. The outcomes of future CEAWeb applications with larger stakeholder groups may inform the development of funding opportunities for emerging materials across the scientific community (e.g., National Science Foundation Science to Achieve Results [STAR] grants, National Institutes of Health Requests for Proposals).

Published by Elsevier B.V.

Abbreviations: CEA, comprehensive environmental assessment; CEAWeb, CEA web interface; CEAPrioritize, CEA spreadsheet tool; ENM, engineered nanomaterials; E–RRF, element–risk relevance factor pair; HERO, Health and Environment Research Online; MCDA, multi-criteria decision analysis; MWCNTs, multiwalled carbon nanotubes.

* Corresponding author. Tel.: +1 919 541 5504.
E-mail addresses: powers.christina@epa.gov (C.M. Powers), kgrieger@rti.org (K.D. Grieger), chendren@duke.edu (C.O. Hendren), meacham.connie@epa.gov (C.A. Meacham), gurevich.gerald@epa.gov (G. Gurevich), lassiter.meredith@epa.gov (M.G. Lassiter), emoney@rti.org (E.S. Money), jml@rti.org (J.M. Lloyd), steveb@rti.org (S.M. Beaulieu).
[1] Tel.: +1 919 541 7243; fax: +1 919 541 7155.
[2] Tel.: +1 919 660 5193.
[3] Tel.: +1 919 541 3908.
[4] Tel.: +1 919 541 2009.
[5] Tel.: +1 919 541 3200.
[6] Tel.: +1 919 541 8845.
[7] Tel.: +1 919 541 5942.
[8] Tel.: +1 919 541 7425.

0048-9697/$ – see front matter. Published by Elsevier B.V.
http://dx.doi.org/10.1016/j.scitotenv.2013.10.016

1. Introduction

1.1. Decision support approaches for emerging materials

Data gaps and scientific uncertainties associated with the behavior of emerging materials can limit our ability to quantify environmental health and safety (EHS) risks, resulting in inadequate information for risk managers. Risk management of emerging materials, such as engineered nanomaterials (ENMs), can benefit from innovative methods that: 1) incorporate various aspects of EHS risks, 2) identify sources of uncertainty and data gaps, and 3) consider stakeholder preferences. To demonstrate the development and pilot testing of one such innovative method, this short communication focuses on ENMs as an example class of emerging materials.

In the case of ENMs, researchers have begun to develop assessment tools and approaches that may help guide decisions about the prioritization of research gaps, preferred methods of ENM synthesis, or identification of ENMs that present the "most" or "least" potential risk based on stakeholder values (e.g., Linkov and Seager, 2011; Tervonen et al., 2009; U.S. EPA, 2012b). Many of these methods incorporate components (e.g., product life cycle framework, exposure and hazard considerations, prioritization) recognized as important for moving toward risk analyses and subsequent risk management of ENM (NRC, 2012; OECD, 2012). Yet as noted in a recent review, available approaches for ENM risk analysis often focus on potential risks in occupational settings and have generally not been applied to a wide variety of ENM (Grieger et al., 2012). Both of these shortcomings suggest that the field would benefit from an approach to more quickly evaluate multiple ENM-types in the context of future environmental (including occupational) risk analyses and risk management. Moreover, recent guidance from the National Research Council and others notes the importance of structured approaches to 1) better connect the identification of research gaps with future assessment efforts, and 2) engage stakeholders throughout the risk assessment process (Abt et al., 2010; NRC, 2011; U.S. GAO, 2013). To address these gaps in current approaches (i.e., relatively rapid evaluation, inclusion of environmental and occupational data, connection of research gaps to future assessments, stakeholder engagement) a pilot tool was developed based on an existing approach, comprehensive environmental assessment (CEA).

1.2. The CEA approach

The U.S. EPA CEA approach facilitates a *process* to collect available information within a *framework* and consider expert stakeholder input in decision making on complex EHS problems (Powers et al., 2012). CEA aims to (i) link research planning, risk assessment, and risk management; (ii) structure and integrate complex information from multiple analytical techniques and approaches (e.g., LCA, risk assessment); (iii) engage diverse perspectives to inform near-term or long-term risk management efforts; and (iv) support iterative risk assessment approaches and adaptive risk management through prioritization efforts (Powers et al., 2012). While other risk-based approaches (e.g., life cycle assessment [LCA], human health risk assessment [HHRA]) or decision support approaches (e.g., MCDA, expert elicitation) can support any one of these objectives, CEA adds an approach to manage information from existing assessment and decision support tools (i.e., a meta-assessment) to the decision maker's tool box (Powers et al., 2012). U.S. EPA has recently applied CEA to several types of ENM (U.S. EPA, 2010, 2012a,b). The core components of each CEA application included (1) draft case study documents that use the CEA framework (conceptualized here in Fig. 1)

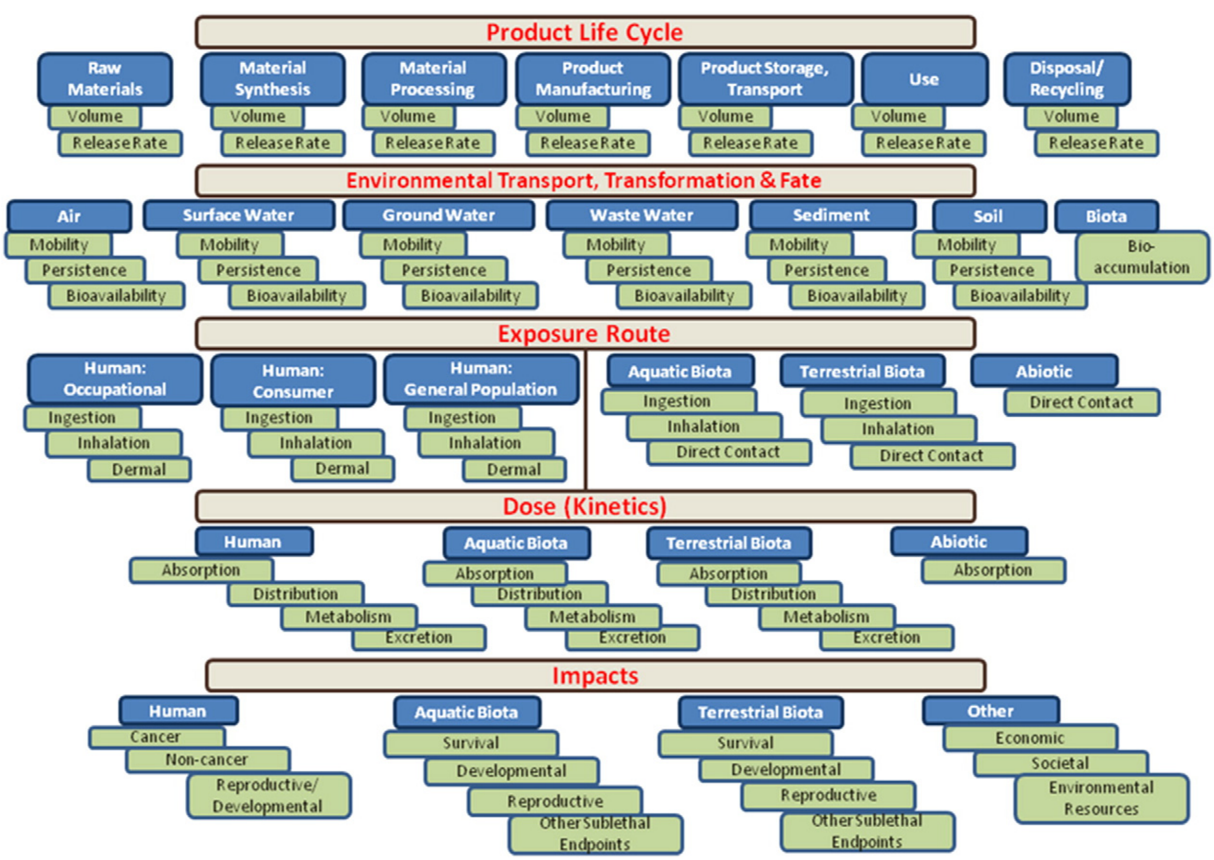

Fig. 1. Detailed CEA framework that provides more granularity to the previously developed framework (see U.S. EPA, 2012a,b). Source RTI International (2012).