Journal of Hazardous Materials 305 (2016) 67–86

Contents lists available at ScienceDirect

Journal of Hazardous Materials

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

Review

Wide-area decontamination in an urban environment after radiological dispersion: A review and perspectives

Michael D. Kaminski[a,*], Sang Don Lee[b], Matthew Magnuson[b]

[a] *Nuclear Decontamination and Separations, Nuclear Engineering Division, Argonne National Laboratory, United States*
[b] *US Environmental Protection Agency, Office of Research and Development, National Homeland Security Research Center, United States*

HIGHLIGHTS

- We review wide area, urban decontamination techniques for rapid response.
- We examine historical data and its application to radiological terrorism scenario.
- Data is insufficient to ensure a detailed, organized mitigation response.
- Primary deficit is lessons-learned and relations to extrapolate a limited data set.
- Research is needed to model a mitigation response and help guide data gathering.

ARTICLE INFO

Article history:
Received 4 March 2015
Received in revised form 6 November 2015
Accepted 9 November 2015
Available online 18 November 2015

Keywords:
Decontamination
Remediation
Radionuclide dispersal device
Nuclear fallout
Radioactive contamination

ABSTRACT

Nuclear or radiological terrorism in the form of uncontrolled radioactive contamination presents a unique challenge in the field of nuclear decontamination. Potential targets require an immediate decontamination response, or mitigation plan to limit the social and economic impact. To date, experience with urban decontamination of building materials – specifically hard, porous, external surfaces – is limited to nuclear weapon fallout and nuclear reactor accidents. Methods are lacking for performing wide-area decontamination in an urban environment so that in all release scenarios the area may be re-occupied without evaluation and/or restriction. Also lacking is experience in developing mitigation strategies, that is, methods of mitigating contamination and its resultant radiation dose in key areas during the *immediate* aftermath of an event and after lifesaving operations. To date, the tremendous strategy development effort primarily by the European community has focused on the recovery phase, which extends years beyond the release event. In this review, we summarize the methods and data collected over the past 70 years in the field of hard, external surface decontamination of radionuclide contaminations, with emphasis on methods suitable for response to radiological dispersal devices and their potentially unique physico-chemical characteristics. This review concludes that although a tremendous amount of work has been completed primarily by the European Community (EU) and the United Kingdom (UK), the few studies existing on each technique permit only very preliminary estimates of decontamination factors for various building materials and methods and extrapolation of those values for use in environments outside the EU and UK. This data shortage prevents us from developing an effective and detailed mitigation response plan and remediation effort. Perhaps most importantly, while the data available does include valuable information on the practical aspects of performing the various remediation methods including costs, coverage rates, manpower, pitfalls, etc., it lacks the details on lessons learned, best practices, and standard procedures, for instance, that would be required to develop a mitigation strategy. While the urban decontamination problem is difficult and there is much more research to do, the existing literature provides a framework for a response plan. Using this framework, in conjunction with computer modeling and relevant data collection, can lead to development of appropriate plans and exercises that would permit development of a mitigation and remediation response.

* Corresponding author. Fax: +1 630 974 4499.
E-mail address: Kaminski@anl.gov (M.D. Kaminski).

http://dx.doi.org/10.1016/j.jhazmat.2015.11.014

Contents

1. Introduction

Nuclear decontamination is a well-established field in the nuclear industry, practiced during routine operations [1] or in decommissioning of a nuclear facility [2]. Decontamination methods include various chemical and physical means of removing radioactivity so that the material may continue in operation, be handled with minimally incurred radiation dose, be disassembled for transport and disposal, etc. While facility decontamination can be a very complicated undertaking, it is considered a small-scale operation compared to cleanup after a large, uncontrolled release of radioactivity to the environment, as was the case with the Chernobyl nuclear reactor accident in 1986 and, most recently, with the reactor accident at Fukushima. The challenges experienced during the resulting remediation of (the process of cleaning-up from) these accidents highlight the limited experience and lack of effective methods for performing wide-area remediation, whether in a rural or urban environment.

But, it is not as though the scientific community has not studied extensively remediation options for these and other nuclear threats. The advent of techniques for nuclear decontamination was in response to concerns over nuclear weapon fallout during the cold war and then with the realization of our unpreparedness for a meltdown accident in a nuclear power reactor. Recently, serious concerns have grown over nuclear terrorism in the form of a kiloton or larger explosion from a crude nuclear fission device (improvised nuclear device, IND) [3] or radiological terrorism via a radionuclide dispersal device (RDD or "dirty bomb") that would scatter radionuclides of cesium, strontium, cobalt, or various actinides (among other possibilities) by low-technology means or by chemical explosives [4].

Both an IND and an RDD could be deployed in an urban area, which would lead to distinct challenges in addressing the objectives of remediation activities. For instance, response to IND and RDD incidents may involve activities designed to reduce contamination and dose levels but not necessarily be optimized for decontamination activities performed as part of the larger cleanup process, which involves characterization, waste treatment, dismantlement, demolition, and disposal work. The activities designed to reduce contamination and dose levels may be instituted to reduce exposure levels during emergency operations or to reopen critical infrastructure during the early phases of incident response "when immediate decisions for effective use of protective actions are required" and "may last from hours to days" [5]. For purposes of this paper, such activities will be referred to as radiological contaminant "mitigation," in which case reductions in contaminations and dose levels may not meet final cleanup levels. All remediation activities may involve the same techniques, but effective application of these techniques during mitigation may make later clean-up activities faster and more effective. An example of mitigation is washing down roadways to allow early responders to continue to utilize these roadways for life saving and property preservation activities. However, if not performed in an appropriate manner, such washing down may spread contamination into critical wastewater infrastructure, impact downstream water uses (such as drinking water utilities that utilize water sources affected by contaminated wash-down water), and other cascading impacts. These cascading