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Analysis of environmental contamination resulting from catastrophic incidents: Part 1. Building and sustaining capacity in laboratory networks

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ABSTRACT

Catastrophic incidents, such as natural disasters, terrorist attacks, and industrial accidents, can occur suddenly and have high impact. However, they often occur at such a low frequency and in unpredictable locations that planning for the management of the consequences of a catastrophe can be difficult. For those catastrophes that result in the release of contaminants, the ability to analyze environmental samples is critical and contributes to the resilience of affected communities. Analyses of environmental samples are needed to make appropriate decisions about the course of action to restore the area affected by the contamination. Environmental samples range from soil, water, and air to vegetation, building materials, and debris. In addition, processes used to decontaminate any of these matrices may also generate wastewater and other materials that require analyses to determine the best course for proper disposal. This paper summarizes activities and programs the United States Environmental Protection Agency (USEPA) has implemented to ensure capability and capacity for the analysis of contaminated environmental samples following catastrophic incidents. USEPA's focus has been on building capability for a wide variety of contaminant classes and on ensuring national laboratory capacity for potential surges in the numbers of samples that could quickly exhaust the resources of local communities. USEPA's efforts have been designed to ensure a strong and resilient laboratory infrastructure in the United States to support communities as they respond to contamination incidents of any magnitude. The efforts include not only addressing technical issues related to the best-available methods for chemical, biological, and radiological contaminants, but also include addressing the challenges of coordination and administration of an efficient and effective response. Laboratory networks designed for responding to large scale contamination incidents can be sustained by applying their resources during incidents of lesser significance, for special projects, and for routine surveillance and monitoring as part of ongoing activities of the environmental laboratory community.

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1. Introduction

The word catastrophe has many definitions, most of which describe an incident that affects large populations and their property for an extended period of time. A catastrophe often involves a complex response that may include the highest levels of government. Another characteristic of catastrophes is that they occur at low frequency and have significant consequences that are difficult to predict with approaches utilized for more routine incidents (Mohtadi and Agiwal, 2012; Mohtadi and Murshid, 2009). Accordingly, a catastrophe is different from an incident which may have significant impacts on a large group of individuals, but involves a lesser impact on society and involvement of government (Quarantelli, 2006). For example, the US Federal Emergency Management Agency (FEMA) defines a catastrophe as "any natural or manmade incident, including terrorism, that results in extraordinary levels of mass casualties, damage, or disruption severely affecting the population, infrastructure, environment, economy, national morale, and/or government functions" (FEMA, 2008). Whether intentional, such as criminal activities or terrorism, or unintentional, such as from industrial accidents or natural disasters, all these incidents (sometimes referred to in the US as "incidents of national significance") can have a profound and long-lasting effect on public and environmental health, society, and economic vitality.

Catastrophes may intentionally or unintentionally cause the release of hazardous chemical, biological, and/or radiological contaminants into the environment. Analyses of environmental samples are needed to make quality decisions about the course of action to restore the area

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affected by the contamination. Because catastrophes are by definition extraordinary in impact, contamination incidents resulting from catastrophes can generate a large number of samples requiring laboratory analyses, involve a variety of matrices, and require complex remediation solutions. In reviewing the responses following the terrorist and anthrax attacks in the United States which occurred 2001, homeland security experts identified ways that the nation could better prepare for response activities across federal, state and local governments (Thompson et al., 2005). One area identified for improvement was the ability of the nation's laboratories to analyze large numbers of samples following catastrophes involving the release of contaminants to the environment. In general, there was a need to increase the nation's laboratory capacity for traditional as well as non-traditional environmental contaminants by either, 1) ensuring large capacity in a few specialty labs, or 2) ensuring that a sufficient number of labs all with some capacity combined could meet demand.

Environmental samples include water, wastewater, soil, air, and surface residue collected on media, and they may come from a multitude of sources. A significant source of samples may be urban materials, such as building materials, both exterior (e.g., concrete, granite, brick and glass) and interior (e.g., drywall, carpet, laminate and ceiling tiles). Contaminated water and wastewater infrastructure may also lead to the collection and analysis of many samples. For example, drinking water distribution systems may be intentionally or accidentally contaminated, and wastewater may be generated from the billions of gallons of water potentially used to decontaminate large areas. Wastewater may also come from the run-off of contaminated precipitation. In urban and suburban areas much of the contaminated water will enter the storm or wastewater collection system, ultimately impacting the wastewater treatment plant and surface waters receiving wastewater plant effluent. In an outdoor contamination incident, building materials (porous and non-porous surfaces), vegetation, and soil may also be contaminated.

It becomes apparent that sampling and analysis methods for many types of environmental samples, each presenting distinct analytical challenges, are necessary for rapid contamination characterization throughout the phases of response. Fig. 1 illustrates the orders of magnitude in the numbers of samples generated during the various phases of a response to a catastrophic incident. Fig. 1 includes not only environmental samples, but also clinical (e.g., bodily fluids from potentially exposed humans) and forensic (e.g., for law-enforcement purposes) samples, as just a few of the types of samples for which analysis may be needed.

The focus of this paper, which is the first in a two-part series, is on environmental samples. During the first few months following an incident, analysis of thousands of environmental samples may be necessary and analysis of significant numbers of samples may be needed for years afterward. The purpose of this series is to provide an overview of the efforts of the USEPA to build capability and capacity for analysis of environmental samples generated primarily during remediation and recovery from contamination incidents resulting from catastrophes. The series also discusses how laboratory networks designed to respond to catastrophes are made sustainable through multi-use application of their resources to incidents of lesser significance and to meet the ongoing demands of the environmental laboratory community.

"Capability" in this two-part series refers to the availability of methods, instrumentation, and trained staff. Selection and development of analytical approaches to ensure availability of methods is discussed in more detail in Part 2 of this series (Magnuson et al., 2014-in this issue). "Capacity" refers to data reporting standards, communication standards, and sufficiency of resources to meet the demand at each stage of remediation and recovery. Part 1 of the series (this paper) focuses mainly on capacity. Capacity and capability to perform laboratory analysis of environmental samples following catastrophes rely on a number of technical and policy factors, and these factors are highly interconnected. In the case of USEPA's efforts, there are many more details than can be summarized below, so this paper focuses only on some of the important topics that may be useful for others seeking to build similar analytical laboratory capability and capacity. For instance, in the European Union, the Standardization of Laboratory Analytical Methods (SLAM) project has an objective of "reviewing the needs for standardization of [chemical, biological, radiological, nuclear, and explosive] analysis and suggesting a road map for its implementation" (EU, 2013).

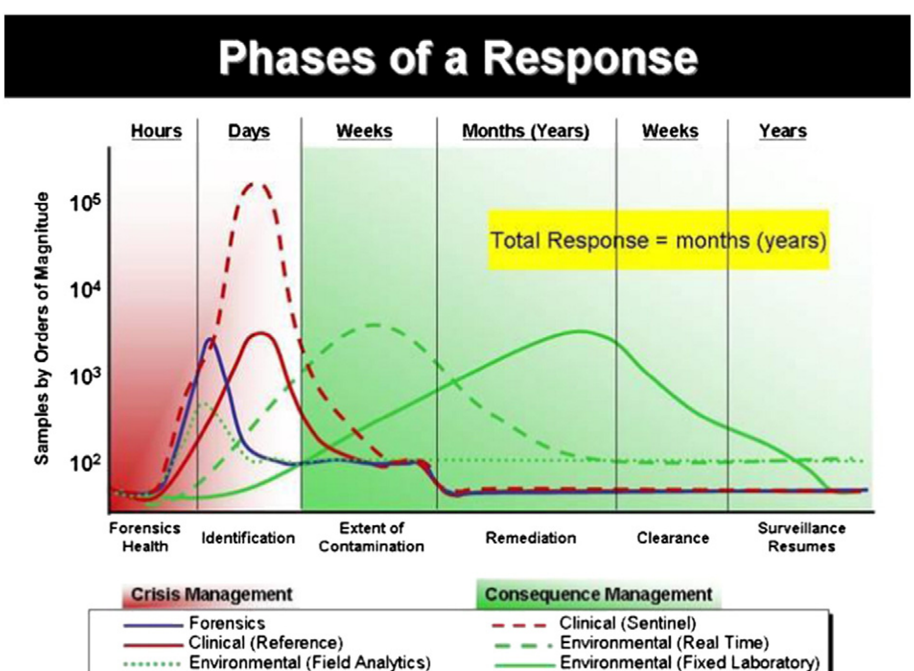

Fig. 1. An illustration of the order of magnitude of samples estimated for different phases of a response to a catastrophic incident. Estimates are provided for forensic (e.g., in support of law enforcement), clinical (from humans, e.g., bodily fluids), and environmental samples. Figure adapted from DHS (2004).