Natural-Technologic Events: The Frequency and Severity of Toxic Releases During and After Natural Disasters with Emphasis on Wind and Seismic Events

by

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ABSTRACT

Toxic substances released from storage facilities, industrial plants, or transportation vehicles as the result of technologic emergencies (e.g., equipment failures, severed pipelines) precipitated by natural disasters are known as natural-technologic or *na-tech* events. The risks associated with na-tech discharges are of importance given accelerated technologic and industrial expansion, increasing population density in disaster-prone areas and trends in the more frequent occurrence of natural disasters. These trends increase the probability of catastrophic future disasters and the potential for mass human exposure to toxic agents released during disasters. Half of the natural disasters that occurred in the United States and its territories during the 1990s resulted in at least one na-tech event. We identified and characterized 1,152 na-tech events that occurred during the 1990s. Of these, 580 were related to wind or seismic effects. Greater knowledge of the factors that resolve the occurrence and severity of na-tech events can be used to increase disaster preparedness levels and damage adsorption capacities.

KEYWORDS: Chemicals; Exposure; Health Effects; Na-tech; Natural Disasters; Toxic

1.0 INTRODUCTION

Subterranean stress, surface instability, high winds, and abnormal precipitation or temperature are natural circumstances that threaten human health (*1*). Rapidly moving or rising floodwaters, damaged roadways, and collapsing buildings are hazards commonly associated with extreme natural events. Oil releases, agrochemical pollution, asbestos dust and other toxic materials released during extreme natural events can also endanger human health. Toxic releases that result from technologic emergencies created by natural disasters have been referred to as natural-technologic or *na-tech* events (*10*).

Na-tech releases pose potential threats to human health through both acute and chronic exposures that may occur when environmental integrity is compromised. Oil, chemical, radiological, or biological agent releases may pose extreme fire and explosive hazards, result in the formation of toxic vapors, or lead to contamination of waterways and groundwater sources (*8, 11, 12*). After a 1995 quake in Kobe City, Japan, dust and irritants raised during demolition work were considered a factor in the deteriorating condition of asthma patients (*7*). In the 1989 Loma Prieta earthquake near Santa Cruz, California, hazardous materials exposures accounted for 20% of after-earthquake work-related injuries (*3*), and numerous human exposures to toxic materials (e.g., asbestos and fiberglass insulation, mercury, leaking transformers, broken chemical containers) (*6*).

A lack of standardized record keeping, however, has hampered efforts to assess the frequency and severity of these occurrences (*10*). As a result, the significance of hazardous material releases in the broad scope of disaster-associated risks has yet to be determined. Na-tech events are a preventable consequence of natural disasters. Na-tech occurrence is the result of technologic circumstances in combination with a natural disaster. Though little can be done to modify the nature of a disaster, the technologic component offers a point of intervention that can be used to diminish or eliminate toxic releases resulting from na-tech causes in disaster situations. In this study, we present estimates of the frequency and character of na-tech incidents

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that occurred in the United States and its territories during the 1990s—with emphasis on wind- and seismic-related na-tech events. Characterization of these events will aid disaster preparedness and mitigation.

2.0 METHODS

We used National Response Center (NRC) records to assess oil, chemical, radiological, and biological discharges occurring in the United States and its territories from January 1, 1990, through December 31, 1999. We used Federal Emergency Management Agency (FEMA) records to identify climatological and geophysical events that occurred in the United States during the same period and resulted in Emergency Declarations or Major Disaster Declarations[2]. A toxic release was identified as a na-tech release if all of the following criteria were met: (1) cause of the release was a "Natural Phenomenon," (2) release day fell within a *disaster period*, (3) state of release and state of FEMA declaration matched, and (4) county of release and county of FEMA declaration matched. Toxic releases attributed to non-natural disasters (e.g., the Oklahoma City bombing) and fire events were removed from analysis.

We characterized na-tech events with respect to: type of natural incident, type of declaration, year of occurrence, type of facility/mode of transportation, location of release (e.g., EPA region), total amount of discharge, and chemical class.

3.0 RESULTS

The NRC recorded 275,032 toxic incidents during the 10-year study period. Of these, 177,464 had sufficient information on the cause, date, and location of the toxic release to facilitate identification of na-tech events. FEMA records indicated that 480 natural, non-fire disasters occurred in the United States and its territories during the same period. Over half of the natural events (52.0%) were associated with at least one na-tech release. The remaining events (47.3%) resulted in no na-tech releases. The number of na-tech releases per event ranged from 0 to 42 with an average of 2.4 na-tech releases per natural event. A total of 1,152 na-tech events were identified.

3.1 General Na-tech Characterization

Nearly half (48.2%) of all na-tech events were generated by wind-related storms, with flood-related storms (30.5%), severe winter storms (19.2%) and earthquakes and aftershocks (2.2%) accounting for the remainder (Figure 1). Further analysis presented in this report focus solely on the 580 na-tech events attributed to wind and seismic events during the 10-year period, unless otherwise noted.

The majority of wind- and seismic-related na-tech events were associated with a major disaster declaration (98.5%). Na-tech events were reported more frequently during the latter half of the decade (61.2%) than during the first half (38.8%). Nearly 73% of all discharges were from fixed facilities (e.g., factories, laboratories) with marine-related and pipeline-associated discharges accounting for 14.5% and 8.8% of releases, respectively. EPA Regions IV and VI experienced the greatest number of na-tech releases—190 and 175, respectively (Figure 2).

3.2 Annual and Geographic Na-tech Fractions and Ratios

The crude na-tech fraction for the period from 1990 through 1999 was 2.1 per 1,000 releases (95% confidence interval [CI]: 2.0-2.2 per 1,000 releases). Analysis of na-tech fractions in 2-year intervals suggested that na-tech occurrence increased during the last two years of the decade (Figure 3). Geographically, the highest na-tech fractions of release occurred in EPA regions IV (4.60 [95% CI: 4.57-4.63]), I (2.37 [95% CI:

[2] An Emergency Declaration can be declared when the President determines Federal assistance is needed to supplement State and local efforts in providing emergency services. A Major Disaster Declaration may be presidentially determined for any natural catastrophe resulting in severe damage exceeding the combined capabilities of State and local governments to respond.

2.36-2.38]), IX (1.97 [95% CI: 1.97-1.98]), and VI (1.87 [95% CI: 1.87-1.88]).

Regions VI (7.3 [95% CI: 5.4-9.9]) and IX (2.9 [95% CI: 2.5-3.5]) exhibited the greatest number of na-tech events per natural event. Earthquakes were associated with 5.00 [95% CI: 4.0-6.3] na-tech events per natural events and wind-related storms were associated with 2.7 [95% CI: 2.4-3.1] na-tech events per natural event.

3.3 Amounts of Toxics Released

In 580 na-tech events, 651 toxic materials were released. Measures of the total volume released were available for a limited number of the 580 na-tech events. Earthquakes and aftershocks (n=10) produced a greater median release volume (3880.0 L) than wind-related storms (n=288; 113.6 L). Release volumes and masses during the period from 1990 through 1994 (median=310.4 L; 453.6 kg) were greater than those between 1995 and 1999 (median=111.7 L; 102.1 kg).

3.4 Types of Toxics Released

Of the 651 hazardous materials released during wind- or seismic-related na-tech events, 465 could be characterized on chemical class. The majority of discharged chemicals (324 [69.7%]), were flammable liquids.

4.0 DISCUSSION

Previously, anecdotal accounts and regional surveys lent evidence to the existence of na-tech events during and after natural disasters (*2, 9, 13, 14*). Our identification of 580 wind- and seismic-related na-tech events during the 1990s reinforces anecdotal descriptions and regionally conducted surveys in demonstrating the existence of na-tech threats.

A 1994 survey of hazards mitigation organizations in 20 states showed an increase in the number of na-tech events during the 1980s (*10*). Our data suggest that wind and seismic na-tech occurrence increased during the 1990s. However, our ability to definitively note trends and make comparisons between groups is limited by the quality of the data.

The NRC data are based on initial release accounts made during or immediately after an incident when exact details may be unknown. As a result, only information that is available early on in the incident is available. Rarely do these early reports indicate the exact amounts released or whether injuries or deaths resulted from a release. Inaccurate, insufficient, or missing NRC data limited the quality of some data and continued to be a problem during our na-tech identification process. One-third of all discharges reported to the NRC did not have sufficient information to allow for determining whether they were na-tech discharges. Voids in the data limit our ability to identify trends and make comparisons, but may also increase the likelihood that the approximations of na-tech occurrence presented here are underestimates of the true occurrence.

Despite the limitations of our study, we identified 580 wind and seismic na-tech events that occurred during the 1990s. In our data, natural events of all types had the potential to result in a na-tech disaster. Windstorms produced the greatest number of na-tech events and earthquakes resulted in the greatest quantities of release. Wind-related storms and earthquakes also had the largest ratios of na-tech events per natural event—indicating that how often some types of natural events occur is not the sole factor determining their relevance with respect to na-tech events. Earthquakes have previously been found to pose the greatest na-tech threat (*10*).

While the frequency of na-tech occurrence appeared to increase during the 10-year period, the median volume and mass of releases decreased. One possible explanation for this paradoxical finding may be that safety measures put in place during the 1990s successfully limited large releases and heightened awareness of na-tech threats, thus increasing the reporting of smaller releases.

5.0 CONCLUSION

Our study reported the occurrence of wind- and seismic-related na-tech events during the 1990s, but was unable to identify significant trends in occurrence. The frequency of na-tech events during the study period suggests that na-tech events may be more pervasive than commonly thought and could be occurring with increasing frequency (*4*, *10*).

Prevention of future na-tech events is the ultimate goal. Some preventative actions that can be taken are identifying and addressing known hazards, providing adequate information and skills to individuals most likely to be exposed or in-contact with toxic agents during or after natural disasters, and increasing municipal and private awareness of the environmental hazards associated with natural disasters. Our study aids such prevention efforts through characterizing the circumstances by which historical na-tech events have occurred in an effort to identify future hazards. The study is also an effective tool for establishing that toxic exposures are occurring in the wake of natural disasters—potentially increasing awareness of disaster-associated environmental hazards and spurring the development of appropriate mitigation and preparedness plans in disaster-prone states and countries that might otherwise have difficulty generating interest in such activities.

Modifying the NRC database or developing a new surveillance tool would yield more useful information on na-tech frequency and more detailed accounts of incidents. Thoroughly characterizing na-tech events will aid in providing communities with accurate and appropriate information so that preparedness levels and damage adsorption capacities can be raised in an effort to thwart future impacts (*5*).

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Figure 1. Type of natural incident associated with na-tech events

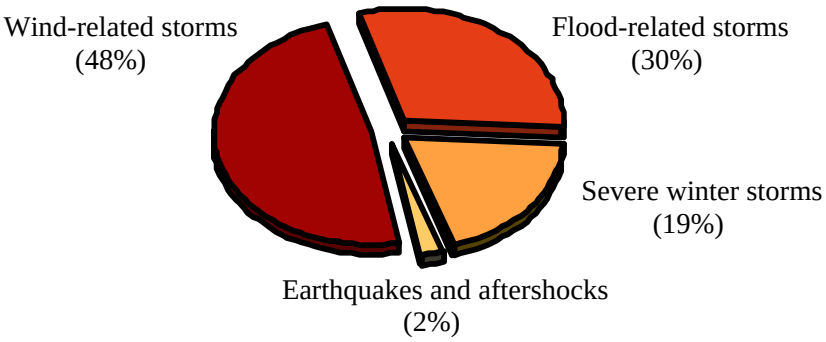

Figure 2. U.S. Environmental Protection Agency (EPA) regions

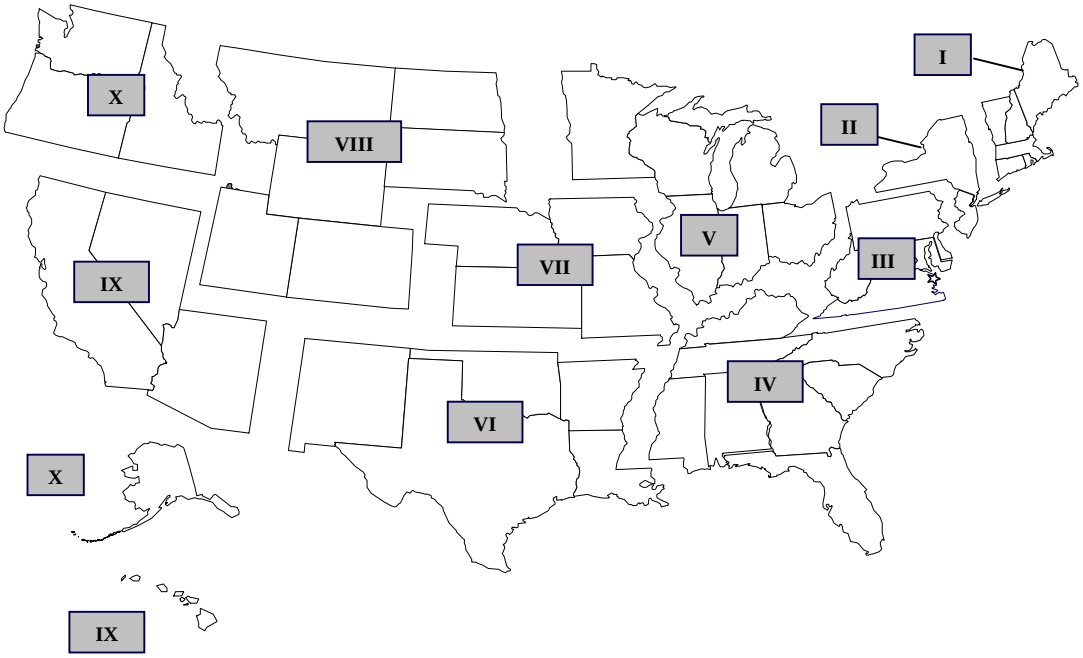

Figure 2. Two-year total NRC toxic releases and na-tech fraction of release per 1,000 NRC releases (95% CI)