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multi-Risk sciEnce for resilienT commUnities undeR a changiNg climate

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1. Technical references

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* PU = Public

PP = Restricted to other programme participants (including the Commission Services)

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1.1. Document history – Part 1

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2. Abstract

In recent years, the rising frequency and severity of NaTech incidents — industrial accidents triggered by natural events such as earthquakes, floods, and storms — has raised growing concern among researchers and risk management authorities. These complex events require the development of specific prevention and management strategies. This study proposes an analysis of 1,300 NaTech incidents over the past 70 years, aiming to identify trends, geographical distribution, and material damages.

The analysis highlights the need for a systematic approach to data collection and organization, as fragmentation and lack of standardization across databases limit the sharing of information. The study also examines NaTech risk assessment methodologies, divided into quantitative and qualitative approaches for natural events such as earthquakes, floods, and storms. The review of these methodologies emphasizes the importance of an integrated approach to risk assessment, helping to improve preparedness and response to future NaTech incidents.

To further illustrate the risks and complexities of NaTech events, the study presents an in-depth analysis of the fire at the TUPRAS refinery during the 17 August 1999 Kocaeli earthquake. This case study highlights the sequence of events, the severe environmental and economic consequences, and the lessons learned from the incident. By examining the structural weaknesses that contributed to the disaster and the subsequent measures taken to enhance safety, the analysis provides actionable insights for improving industrial resilience to natural hazards.

The results underscore the importance of accurately identifying natural hazards, assessing their potential impact on industrial facilities, and developing effective mitigation strategies. Despite advancements in the field, greater efforts toward standardization and international collaboration are essential to improving global readiness and response to NaTech events, ultimately optimizing risk management and environmental safety.

ABSTRACT

In this study, a risk assessment to tornado event was conducted for an atmospheric storage tank.
Given the scope of the study, only the vulnerability analysis of the tank was performed, thus excluding the consequences analysis. The study was carried out following the methodology presented in Santamato and Busini (2025).
The first step of the analysis is the historical review of the tornado events occurred in the area where the tank under investigation is located. This territorial screening was carried out by extracting and classifying tornado events according with the Enhanced Fujita (EF) Scale, using the European Severe Weather Database (ESWD).
The analysis revealed that during the survey period, and in the survey area, 9 events were recorded as EF1, 5 events as EF2, and 2 events as EF3. No events categorized as EF4 or EF5 were reported. For each i-th degree of EF scale, a frequency of occurrence $Fr_{(EF\_i)}$ was estimated considering the number of recorded events, the survey period, the survey area, and the plant surface, according to eq. (1).
The potential damage for the tank was evaluated with respect to three failure mechanisms: overturning, buckling, and debris impact ("puncturing damage").
As a result of the assessment, no potential for overturning nor buckling was identified regardless of the tornado intensity, mainly due to the fill level and the tank design. Conversely, from the vulnerability analysis to debris impact, an increasing probability of damage was found with the intensity of the natural event, ranging from 9% for EF1 to nearly 50% for EF5 tornadoes.
Finally a frequency of occurrence was assigned to the top event, i.e., LOC from the storage tank under analysis due to tornado impact, conservatively assuming certain the loss of containment following tank damage. Since the damage can occur as a result of any of the three mechanisms investigated, and due to tornadoes classified with any of the category of the Enhanced Fujita scale, the total damage probability can be calculated by multiplying, for each degree of intensity, the frequency of occurrence of the event by the probability of tank damage, and then summing the three contributions from the three damage mechanisms.

1. Abstract

NaTech events (Natural-Hazard Triggered Technological Accidents) arise from the interplay between natural phenomena and technological incidents involving the release of hazardous substances. Predicting occupational inhalation risks in industrial areas is particularly challenging in the context of NaTech events due to the difficulty in predicting concentration fields, due to the presence of built elements that induce air flow perturbation. In this work, a methodology for the preventive assessment of the risk associated with the accidental inhalation of toxic substances on an industrial site is presented. The methodology is based on NaTech sequence modelling: event and site characterization; simulation of the accidental release and pollutant dispersion; calculation of short-term risk by averaging concentrations and comparing them with the reference values proposed by the main occupational exposure organizations worldwide. The proposed model is applied to a case study corresponding to a chemical company located in central Italy. A NaTech event (vessel failure caused by a flooding) leads to a pool release, evaporation, and dispersion of tetrahydrofuran. A pool evaporation model is applied, and the Lagrangian particle model Parallel Micro-Swift Spray (PMSS) is used for dispersion modelling. The resulting tetrahydrofuran concentration within the industrial area is between 0 and 596 mg m-3 for both stable and unstable atmospheric conditions. The concentration decreases rapidly with the distance from the source. Areas of pollutant accumulation are present near the buildings, caused by recirculation phenomena occurring in the air flow field. The inhalation risk is negligible from around 10 meters distance from the source. However, the threshold limit value for short-term exposure (TLV-STEL) of 100 ppm is exceeded 23 times during the event. The uncertainty on the calculated risk uncertainty arises by considerations on modelling choices, threshold limit values, and the correction method for short-term concentration averaging. On the proposed general methodology, the presented model can be applied with relatively limited resources in terms of calculation resources and practical applicability. The general approach needs to be tested extensively and integrated with analysis of NaTech events dynamics and existing consolidated methodologies for quantitative risk analysis.