ABSTRACT PROCEEDINGS

The 6th International Symposium on Natural Hazard-Triggered Technological Accidents

Global Perspectives for Natech Risk Management

UNGRD
Unidad Nacional para la Gestión del Riesgo de Desastres
Sistema Nacional de Gestión del Riesgo de Desastres

大阪大学
OSAKA UNIVERSITY

KYOTO UNIVERSITY
KYOTO JAPAN
FOUNDED 1897

DPRI-KU

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The 6th International Symposium on Natural Hazard-Triggered Technological Accidents

Global Perspectives for Natech Risk Management

NATECH 2022

Mach 10 and 11

National Unit for Disaster Risk Management

Kyoto University – Disaster Prevention Research Institute-DPRI

Osaka University

National Unit for Disaster Risk Management
Calle 26 # 92 - 32, Building Gold 4 – 2nd floor

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NATIONAL UNIT FOR DISASTER RISK MANAGEMENT

It is a Special Administrative Unit of the Executive Branch, of the national order, attached to the Administrative Department of the Presidency of the Republic, its objective is to direct the implementation of disaster risk management, attend to sustainable development policies, and coordinate the operation and the continued development of the country's National System for Disaster Risk Management (SNGRD).

Mission

The Unit directs, guides, and coordinates Disaster Risk Management in Colombia, strengthening the capacities of public, private, community entities and society in general, with the explicit purpose of contributing to the improvement of people's quality of life and sustainable development, through risk knowledge, its reduction and the management of disasters associated with phenomena of natural, socio-natural, technological and unintentional human origin.

Vision

By 2030, the Unit will be recognized as the entity that coordinates, articulates, and strengthens the National System for Disaster Risk Management (SNGRD) in the understanding of disaster risk, the incorporation of Comprehensive Risk Management in the culture of Colombians, risk reduction, preparation for emergency response, the timely and adequate response and orientation of disaster recovery processes with a focus on resilience and sustainable development; reducing risk conditions, losses and costs associated with disasters.

UNGRD
Unidad Nacional para la Gestión del Riesgo de Desastres
Sistema Nacional de Gestión del Riesgo de Desastres

KYOTO UNIVERSITY

Kyoto University is located in Kyoto (Japan), a city with a rich East Asian cultural heritage. Kyoto University's Fundamental Principles include the promotion of international educational and research activities.

Kyoto University, the second oldest university in Japan, was established in 1897 as Kyoto Imperial University. Since then, the university has grown, and as of 2017, the University has ten Faculties, eighteen Graduate Schools, thirteen Research Institutes, and twenty-two Research and Educational Centers. Kyoto University is ranked among the top 50 best universities in the world (see for example https://www.shanghairanking.com/institution/kyoto-university). This is testified by the many awards and honors conferred to its researchers, including eleven Nobel Prizes, with the most recent Nobel Prize in Chemistry given to Prof. Akira Yoshino in 2019.

Among its research institutes is the Disaster Prevention Research Institute (DPRI) dedicated to natural hazard risk reduction, establishing integrated methodologies for disaster loss reduction, and educating students in related fields. DPRI promoted interdisciplinary theoretical and applied research on various disaster-related themes at the local to global scales from the viewpoints of natural science, engineering, and human and social sciences. Among the work being carried out at DPRI, the Disaster Risk Management Laboratory aims to promote strategic risk governance of techno-social systems in an effort to contribute to societal resilience to some of the complex disaster risks our planet is faced with. Particularly our efforts are centered around risk reduction of conjoint natural and technological (Natech) disaster risks including risks arising from major chemical accidents involving hazardous materials and environmental emergencies.

For more information, please visit the following links:

- Kyoto University website:
  https://www.kyoto-u.ac.jp/en
- Kyoto University introductory brochure:
  https://www.kyoto-u.ac.jp/en/about/publications/kyotouniversityintroductorybrochure

- Disaster Prevention Research Institute website:
  https://www.dpri.kyoto-u.ac.jp/en/
- Disaster Risk Management Laboratory:
  https://www.dpri.kyoto-u.ac.jp/organization_en/iasdrrg_en/drs/drm/

OSAKA UNIVERSITY

Osaka is one of the biggest metropolitan areas in Japan. Though the prefecture itself is the second smallest nationwide, it ranks third economically, and has the third highest population. About nine percent of all foreign residents make Osaka their home, and it is the second most popular destination for study abroad students. It is the center of the Kansai region: an area composed of Osaka, Kyoto, and several other prefectures, and has fast, efficient public transport to travel quickly to and from the surrounding areas. Despite being a sprawling metropolis, The Economist ranked Osaka third in the world in their Safe Cities Index in 2019 and fourth in the Global Livability Index in 2019.

Although officially founded in 1931 as Japan's 6th imperial university, you may be interested to learn that Osaka University's roots reach back to1838 and Tekijuku, a private "place of learning" founded by OGATA Koan. The university has from its birth inherited the spirit of the citizens of Osaka. With this spirit and with the motto "Live Locally, Grow Globally," Osaka University has always--and across generations--responded to the challenges of society.

School of Engineering, Osaka University celebrated its 120th anniversary in 2016. Since its founding, we pioneered a lot of promising fields from our unique perspective as well as core engineering fields, and thus established Japan-first brand-new departments. Nowadays, we have five undergraduate divisions: Applied Science, Mechanical, Materials and Manufacturing Science, Electronic and Information Engineering, Sustainable Energy and Environmental Engineering, and Global Architecture. School of Engineering has become among the largest in Japan accepting 820 new students every year.

Graduate School of Engineering is the main body of education and research at Osaka University, consisting of nine divisions/departments and six research centers. More than 170 laboratories cover diverse areas to aim at solving all the problems in our society. 811 students enter the Master course at the Graduate School, about 80% of whom are graduated from School of Engineering. In addition, many foreign students from over 50 countries are included in Ph.D. candidates. The faculty members and graduate students are enthusiastically co-working to pursue the top-level researches.

For more information, please visit the following links:

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- Osaka University website: *https://www.osaka-u.ac.jp/en*
- Osaka University introductory brochure: *https://www.osaka-u.ac.jp/en/guide/public-relations/prospectus_folder/prospectus_2021*
- School/Graduate School of Engineering, Osaka University website: *https://www.eng.osaka-u.ac.jp/en/*

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PREFACE

The Natech symposium has been taking place since 2015, as an initiative of professors Naomi Kato, Shin-ichi Aoki and Ana María Cruz, from Osaka University and Kyoto University respectively. The primary objective of these symposiums has been the promotion of scientific and interdisciplinary exchange of experiences, risk assessment methods and innovative risk reduction measures that address Natech events (industrial accidents caused by large-scale natural events).

In its different versions it has had researchers and participants from different countries, allowing the integration of initiatives and efforts that have been developed in this regard.

The first symposium was held in March 2015 at Osaka University, and was entitled: *International Symposium on Natural Disaster Impacts to Large Industrial Parks*, it was funded by the Graduate School of Osaka University, the Airport and Port Research Institute (SIP), the Disaster Prevention Research Institute, and Kyoto University, in cooperation with the Calamity Science Institute.

The second version of the event entitled: *Activities of Research Initiatives for Natural Disaster Prevention of Oil and Gas Spill in Industrial Parks* was held again at Osaka University in 2016.

In March 2017, symposium number three was organized by the Disaster Prevention Research Institute (DPRI) and took place at Kyoto University. On this occasion, it was approached from the perspective of a workshop on Natech risk management tools, with the aim of making a practical demonstration of some tools available for Natech risk assessment, risk mitigation and emergency operations' planning for various types of natural hazards. The workshop was attended by participants from 12 countries, including experts, students and stakeholders involved in Natech disaster risk reduction and similar topics.

During 2018, the event moved to Ispra, Italy, where the Joint Research Center (JRC) of the European Commission and the University of Bologna were the hosts. On this occasion, the fourth event was named *Natech Risk Reduction at Large Industrial Parks*.

The fifth version of the Natech symposium was held in 2021, again organized by Osaka University and Kyoto University. On this occasion, given the restrictions derived from the COVID-19 pandemic, the event was held virtually. Currently, the publication of two volumes in the IDRIM Springer Nature Book Series is being issued, which will be released by the end of 2022.

This year (2022) Colombia was the host country of the sixth version of the Natech symposium, which was developed in a hybrid way (face-to-face and virtual), being the first time that this event is held in the American continent. On this occasion, the organizers of the event were the National Unit for Disaster Risk Management (UNGRD), Osaka University, Kyoto University and the Disaster Prevention Research Institute (DPRI). This event focused on the exchange of research experiences and lessons learned related to risk management of technological accidents triggered by natural events (Natech), for their understanding and approach in the Colombian territory.

Participation was massive with over 1800 people registered from 42 different countries including Colombia, Japan, China, France, Italy, Croatia, England, Poland, Russia, Indonesia, Malaysia, Thailand, Canada, USA, Mexico, Peru, Chile, Ecuador, Argentina, Venezuela, among others. We had 202 face-to-face participants and 1,033 registered users on the virtual platform. In addition, many interested people followed the sessions through YouTube and Facebook. To look at the recordings of the sessions you can access the following links:

DATE	**YOUTUBE** Auditorium	**FACEBOOK** Parallel Sessions
Day 1 March 10	https://youtu.be/hWBwHgWM04w	https://www.facebook.com/GestionUNGRD/videos/1056273481769983/
Day 2 March 11	https://youtu.be/MoZeBM8mlCk	https://www.facebook.com/GestionUNGRD/videos/219400757039750/

As evidenced, the Natech symposium has been growing over the years and is increasingly relevant, given the topics it addresses, which are aligned with the Sendai Framework, the SDGs and the OECD requirements regarding the inclusion of this type. of scenarios in risk analysis. In addition, the experiences, knowledge and lessons learned from the different countries provide tools so that Natech risk reduction measures can be strengthened worldwide, which highlights the importance of international cooperation.

OBJECTIVE

Exchange research experiences and lessons learned in the risk management of technological accidents triggered by natural events, for their understanding and approach in the Colombian territory.

SESSIONS

1. Public stakeholder initiatives for Natech Risk Management
2. Tsunami Natech Risk Assessment
3. Natech Research: Case Studies in Colombia
4. Advances in Natech Risk Communication, Perception, and Education
5. Natech Risk Factors Modeling
6. Natech Risk and Emergency Response in Colombia
7. Natech Risk in Hazardous Materials Transmission Pipelines
8. Methodologies and Tools for Holistic, Systemic, and Cascading Risk Analysis

SYMPOSIUM STATISTICS

1.885 Registered

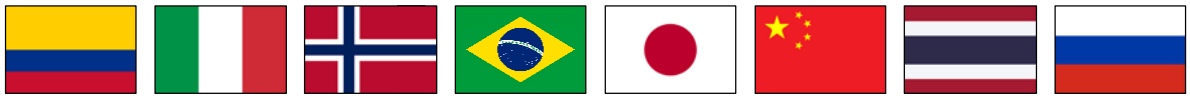
42 Countries

32 Departments

253 Municipalities

202 Face-to-Face Participants

29 *Panelists participated from 8 countries*



2.279 Interactions

YouTube

771 Reproductions

facebook

SYMPOSIUM PROGRAM

NATECH 2022
6to Simposio Internacional de Accidentes Tecnológicos Desencadenados por Eventos de Origen Natural

Schedule

6th International Symposium on Natural Hazard-Triggered Technological Accidents: Global Perspectives for Natech Risk Management

FIRST DAY			
TIME (COL) March 10th	TIME (CET) March 10th	TIME (JST) March 11th	Event
17:00 - 17:20	23:00 - 23:20	7:00 - 7:20	**Opening**
17:20 - 17:45	23:20 - 23:45	7:20 - 7:45	**PLENARY SESSION** Felipe Muñoz *ECOPETROL*

TIME			1ST DAY MAIN SESSION	1ST DAY PARALLEL SESSION (ONLINE)
(COL) March 10th	(CET) March 10th	(JST) March 11th	**1st session** **Public stakeholder initiatives for Natech Risk Management** Chair: María Camila Suárez	**3rd session** **Natech Research: Case Studies in Colombia** Chair: Alexander Guzmán
17:45 - 18:00	23:45 - 00:00	7:45 - 8:00	**NATECH'S EFFORTS IN THE COLOMBIAN MINING AND ENERGY SECTOR** Elsa Lorena Sánchez Gómez *Ministry of Mines and Energy, Colombia* (SPANISH, ENGLISH, JAPANESE, ON-SITE)	IDENTIFICATION AND ANALYSIS OF LANDSLIDE EVENTS IN HYDROCARBON TRANSMISSION PIPELINES Lina Parra *Graduate School of Engineering, University of Kyoto, Japan* (SPANISH, VIRTUAL)
18:00 - 18:15	00:00 - 00:15	8:00 - 8:15	**A NATECH HYDROCARBON EVENT THAT COULD HAVE BEEN AVOIDED IN PUTUMAYO** Gladys Puerto *National Environmental Licensing Agency (ANLA), Colombia* (SPANISH, ENGLISH, JAPANESE, ON-SITE	**MULTITEMPORAL EVALUATION OF COMMUNITY RESILIENCE TO TECHNOLOGICAL RISK DISASTERS IN COMMUNE 10 OF THE MUNICIPALITY OF DOSQUEBRADAS** Evelin Langebeck y Nicolás Giraldo Hernández *Faculty of Engineering and Architecture, Catholic University of Manizales, Colombia* (SPANISH, VIRTUAL)
18:15 - 8:30	00:15 - 00:30	8:15 - 8:30	**METHODOLOGY FOR THE DETERMINATION OF NATECH SCENARIO VULNERABILITY INDEXES TO BE INCLUDED IN THE METROPOLITAN AREA OF THE ABURRÁ VALLEY TERRITORIAL MANAGEMENT** Marco Fidel Gamboa *EAFIT University, Colombia (Author)* *Metropolitan Area of Aburrá Valley (Contracting Entity)* (SPANISH, ENGLISH, JAPANESE, ON-SITE)	**CONSIDERATIONS FOR A MORE INCLUSIVE NATIONAL CONTINGENCY PLAN: KNOWLEDGE OF TRADITIONAL AND NON-TRADITIONAL COMMUNITIES** Itzayana González *Federal University of Rio Grande do Sul, Brazil* (SPANISH, VIRTUAL)
18:30 - 18:40	00:30 - 00:40	8:30 - 8:40	**Q&A session**	**Q&A session**
18:40 - 18:50	00:40 - 00:50	8:40 - 8:50	**Coffee Break and stands**	**Coffe Break**

(COL) March 10th	(CET) March 11th	(JST) March 11th	2nd session Tsunami Natech Risk Assessment Chair: Aoki Shin-ichi	4th session Advances in Natech Risk Communication, Perception, and Education Chair: Subhajyoti Samaddar
18:50 - 19:05	00:45 - 1:05	8:50 - 9:05	**THE URGENT NEED TO CARRY OUT PROBABILISTIC TSUNAMI HAZARD STUDIES IN COLOMBIA: IMPLICATIONS FOR THE PORT, FISHING AND OIL INDUSTRY** Erick Velasco-Reyes *Earth Science Department, Tohoku University, Japan* (SPANISH, ENGLISH, JAPANESE, VIRTUAL)	**A MULTIPLE PERSPECTIVE ON THE STATE OF NATECH RISK MANAGEMENT** Yiwen Pan *Institute for Disaster Management and Reconstruction, Sichuan University, China* (ENGLISH, VIRTUAL)
19:05 - 19:20	1:05 - 1:20	9:05 - 9:20	**TOWARDS PROBABILISTIC TSUNAMI-TRIGGERED OIL SPILL FIRE HAZARD ASSESSMENT: A PRELIMINARY UNCERTAINTY ANALYSIS** Tomoaki Nishino *Disaster Prevention Research Institute, Kyoto University, Japan* (SPANISH, ENGLISH, JAPANESE, VIRTUAL)	**THE SIGNIFICANCE OF THE INTERNAL AND EXTERNAL SYNERGISTIC EFFECTS IN NATECH HAZARDS** Zhichao He *Institute of Public Safety Research, Department of Engineering Physics, Tsinghua University, Key Laboratory of Comprehensive Emergency Response Science, China* (ENGLISH, VIRTUAL)
19:20 - 19:35	1:20 - 1:35	9:20 - 9:35	**RISKS ASSOCIATED WITH FLOATING OBJECTS AROUND COASTAL BUILT ENVIRONMENTS DURING TSUNAMI** Renne Josiah *Osaka University, Japan* (SPANISH, ENGLISH, JAPANESE, VIRTUAL)	**A SERIOUS GAMING APPROACH FOR NATECH RISK AWARENESS AND CHEMICAL INFORMATION DISCLOSURE** Dimitrios Tzioutzios *Department of Urban Management, Graduate School of Engineering, Kyoto University, Japan* (ENGLISH, VIRTUAL)
19:35 - 19:50	1:35 - 1:50	9:35 - 9:50	**OIL SPILL SIMULATION CAUSED BY TSUNAMI AND EVALUATION OF THE GOVERNMENT'S MEASUREMENTS AT OSAKA BAY** Shoken Nakase *Yokohama National University, Japan* (SPANISH, ENGLISH, JAPANESE, VIRTUAL)	**INEQUALITY TO NATECH RESILIENCE: SOCIAL DIMENSIONS IN NATECH VULNERABILITY ANALYSIS** Khanin Hutanuwatr *Urban and Regional Planning Program, Faculty of Architecture Art and Design, King Mongkut's Institute of Technology Ladkrabang, Thailand* (ENGLISH, VIRTUAL)
19:50 - 20:05	1:50 - 2:05	9:50 - 10:05	**RISK ASSESSMENT OF SECONDARY DISASTERS BY TSUNAMI DEBRIS IN OSAKA BAY WITH OCEAN AND INUNDATION MODEL CONSIDERING METEOROLOGICAL EXTERNAL FORCES** Masayasu Irie *Osaka University, Japan* (SPANISH, ENGLISH, JAPANESE, VIRTUAL)	**EXPANDING THE NATECH HORIZON BY CONSIDERING IMPLEMENTATION: WHY AN ALUMINUM FACTORY EXPLOSION WAS A SURPRISE TO THE LOCAL COMMUNITY** Norio Okada1 and Robert Goble2 *1 Kwansei Gakuin University, Japan* *2 Clark University, USA* (ENGLISH, VIRTUAL)
20:05 - 20:15	2:05 - 2:15	10:05 - 10:15	**Q&A session**	**Q&A session**
20:15 - 20:20	2:15 - 2:20	10:15 - 10:20	**First day closing and acknowledgments, Lina Dorado**	

SECOND DAY			
(COL) March 11th	(CET) March 11th	(JST) March 11th	Event
8:00 - 8:05	14:00 - 14:05	22:00 - 22:05	2nd day opening, Lina Dorado

TIME			2ND DAY MAIN SESSION (AUDITORIUM)	2ND DAY PARALLEL SESSION (ONLINE)
(COL) March 11th	(CET) March 11th	(JST) March 11th	**5th session** **Natech Risk Factors Modeling** Chair: Guoyi Han	**7th session** **Natech Risk in Hazardous Materials Transmission Pipelines** Chair: Mauricio Sánchez
8:05 - 8:20	14:05 - 14:20	22:05 - 22:20	**ASSET PERFORMANCE MANAGEMENT FOCUSING ON GEOHAZARD ANALYSIS** Jaime Hernán Aristizábal Ceballos *CENIT Transport and Logistics of Hydrocarbons, Colombia* (SPANISH, ENGLISH, JAPANESE, VIRTUAL)	**DEVELOPING A SIMPLIFIED MODEL FOR ASSESSING THE PIPELINE FAILURE PROBABILITY DUE TO MULTIPLE INDEPENDENT SOURCES OF RAINFALL-INDUCED DEBRIS FLOW** Su Song *Kyoto University, Japan* (ENGLISH, VIRTUAL)
8:20 - 8:35	14:20 - 14:35	22:20 - 22:35	**AN INNOVATIVE ACCIDENT PARADIGM TO SUPPORT A COMPREHENSIVE NATECH RISK ASSESSMENT** Alessio Misuri *LISES – Laboratory of Industrial Safety and Environmental Sustainability, University of Bologna, Italy* (SPANISH, ENGLISH, JAPANESE, VIRTUAL)	**ASSESSMENT OF FAILURE FREQUENCIES OF PIPELINES CAUSED BY EARTHQUAKES IN NATECH FRAMEWORK** Fabiola Amaducci *University of Bologna, Italy* (ENGLISH, VIRTUAL)
8:35 - 8:50	14:35 - 14:50	22:35 - 22:50	**HOW WE ASSESS THE NATECH RISK UNDER A CHANGING CLIMATE?** Xiaolong Luo Institute for Disaster Management and Reconstruction, Sichuan *University, China* (SPANISH, ENGLISH, JAPANESE, VIRTUAL)	**WHAT HAVE WE ADVANCED IN NATECH APPROACHES IN PIPELINES?** Rafael Amaya Gómez *Los Andes University, Colombia* (ENGLISH, VIRTUAL)
8:50 - 9:05	14:50 - 15:05	22:50 - 23:05	**ANALYZING THE FATE OF HAZARDOUS MATERIALS RELEASED IN FLOODWATERS** Amos Necci *European Commission Joint Research Centre, Italy* (SPANISH, ENGLISH, JAPANESE, VIRTUAL)	**Q&A session**
9:05 - 9:15	15:05 - 15:15	23:05 - 23:15	**Q&A session**	
9:15 - 9:35	15:15 - 15:35	23:15 - 23:35	Coffee Break and stands	Coffee Break

(COL) March 11th	(CET) March 11th	(JST) March 11th	6th session **Natech Risk and Emergency Response in Colombia** Chair: Lina Dorado	8th session **Methodologies and Tools for Holistic, Systemic, and Cascading Risk Analysis** Chair: Valerio Cozzani
9:35 - 9:50	15:35 - 15:50	23:35 - 23:50	**AN OVERVIEW OF NATECH RISKS IN COLOMBIA** María Camila Suárez *National Unit for Disaster Risk Management, Colombia* (SPANISH, ENGLISH, JAPANESE, ON-SITE)	**THE SYNERGY OF VEGETATION AND METEOROLOGICAL CONDITIONS AFFECTING THE NORWEGIAN POWER GRID: AN EXAMPLE OF NATECH RISK INFLUENCING FACTOR** Nicola Paltrinieri *Department of Mechanical and Industrial Engineering, Norwegian University of Science and Technology, Norway* (ENGLISH, VIRTUAL)
9:50 - 10:05	15:50 - 16:05	23:50 - 00:05	**DISASTER MANAGEMENT AND EMERGENCY RESPONSE IN THE NATECH CONTEXT: THE CASE OF THE MUNICIPALITY OF FACATATIVÁ** Gerson David Cordero E. *Facatativa Municipal Mayor's Office, Colombia* (SPANISH, ENGLISH, JAPANESE, ON-SITE)	**SAFETY DISTANCES TO AVOID NATECH ACCIDENTS CAUSED BY WILDFIRES IN THE WILD-INDUSTRIAL-INTERFACE** Federica Ricci *Department of Civil, Chemical, Environmental, and Materials Engineering, LISES Group – Laboratory of Industrial Safety and Environmental Sustainability, University of Bologna, Italy* (ENGLISH, VIRTUAL)
10:05 - 10:20	16:05 - 16:20	00:05 - 00:20	**GUIDELINES OF THE NATIONAL NAVY FOR EMERGENCY RESPONSE TO SPILLS OF NOXIOUS SUBSTANCES** Angel Leonardo Rojas Rodriguez *Admiral Padilla Naval Cadet School, Colombian Navy, Colombia* (SPANISH, ENGLISH, JAPANESE, ON-SITE)	**NATECH ACCIDENT MONITORING AND RISK ANALYSIS USING DATABASE** Elena Petrova *Faculty of Geography, Lomonosov Moscow State University, Russia* (ENGLISH, VIRTUAL)
10:20 - 10:30	16:20 - 16:30	00:20 - 00:30	**Q&A session**	**Q&A session**
10:30 - 11:00	16:30 - 17: 00	00:30 - 01:00	**PANEL SESSION AND CLOSING** Professor Ana Maria Cruz	

1st session

PUBLIC STAKEHOLDER INITIATIVES FOR NATECH RISK MANAGEMENT

Chair:

MARÍA CAMILA SUÁREZ PABA
National Unit for Disaster Risk Reduction
COLOMBIA

Natech's Efforts in the Colombian Mining and Energy Sector

ELSA SÁNCHEZ GÓMEZ[1*]

Sofía Roa Lozano[2]

Ministry of Mines and Energy, Office of Environmental and Social Affairs, Bogotá COLOMBIA

Member of the Disaster Risk Management Group[1], Coordinator of the Disaster Risk Management Group Grupo[2]

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Today, NATECH scenarios represent great challenges for public institutions from the analysis of the relationships between the different types of events and their concatenations. For the mining-energy sector, this NATECH concept represents the materialization of highly complex scenarios, which affect the biophysical relationships and configurations of the territory and the development of the sector's activities (exploration and exploitation of minerals and hydrocarbons, and generation of electrical energy).

However, it is key to clarify that when it comes to disaster risk management, the mining-energy sector plays a double role in these relations with the territory: a passive role in terms of infrastructure vulnerability and continuity of service or operations, and a active role in which various accidental events can be triggered during the development of sub-sectoral activities.

The Ministry of Mines and Energy began the diagnostic process of the policy, with the collection and analysis of data on sub-sectoral accidental events, in order to classify and establish the recurring scenarios of technological origin and those prospective risk scenarios that incorporate a predisposition of natural conditions in the territory, which can trigger events of technological origin. The sector is not unaware that the territories already contain pre-existing hazardous conditions of natural origin on which both the occupation models and the development of various economic activities in the territory are written and rewritten, like a palimpsest.

At the same time, this process of approaching the knowledge of technological and NATECH risks was complemented with an analysis of institutional capacities, which reflected great challenges for sectoral institutions in relation to governance, risk reduction and disaster management, which laid pillars for the formulation and agreement process (with public and private actors) of the disaster risk management policy for the mining-energy sector, adopted through resolution 40411 of December 23, 2021, aimed at:

Optimize process safety by increasing technical, social and environmental quality standards, which will result in the safety of the territories and their communities. In addition to strengthening institutional capacities in disaster risk management and minimizing the economic, social and environmental losses of the sector and the territories, among other purposes.

Through the proposed working route 2022 - 2026, the actions oriented from each structural and transversal axis of the policy will be delved into, for example: Generate and update the information and mapping of accidental events of technological and NATECH origin for the subsectors of mines, hydrocarbons and electrical energy (conventional and non-conventional) and its infrastructure

Finally, some of the sub-sector advances that directly and indirectly incorporate technological risk management such as NATECH from regulatory instruments, guides and other initiatives will be highlighted.

KEYWORDS

Disaster Risk Management Policy for the Mining-Energy Sector, Active Role, Passive Role, Value Chain, Subsector

A Natech Hydrocarbon Event That Could Have Been Avoided in Putumayo

ALEJANDRA ISABEL ALMARIO

Gladys Puerto Castro*

National Authority for Environmental Licenses - ANLA, Bogotá COLOMBIA

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What happened?

At dawn on June 21, 2020, a spill of approximately 50 bbls of crude oil occurred due to the loss of containment in the 6" transfer line at the subfluvial crossing in Mocoa River. The initial cause reported was the rapid rise of the river due to strong rains in days prior to the event. It is reported that the released hydrocarbon traveled approximately 60 km through the channels of the Mocoa and Caquetá rivers (Putumayo department, Colombia).

What actions were taken to deal with the contingency?

- Activation of the Contingency Plan
- Suspension of oil pumping
- Installation of three control points
- Notification of the event to authorities
- Survey of damages
- Cleaning actions of affected areas

What background did they have?

As a consequence of the follow-up to the contingency, the ANLA required the owner of the control and management instrument to "Submit a report on the maintenance and monitoring carried out on the flow line at the height of the Puerto Limón village (site of the contingency)" , against which the topographical study of the subfluvial oil pipeline crossing over the Mocoa River was carried out, to determine the depths at which the flow line is buried, a critical point is identified on the abscissa K0+382 where it is identified that the depth of the pipeline is 0.30 meters. On the recommendation of the bathymetry study, in 2016 a protection dyke was built 300 meters upstream of the pipeline with the aim of drying the river arm and building protection barriers for the pipe, however, the dyke was destroyed by the force of the water, due to the fluviotorrential event of August 12, 2018 that occurred in Mocoa (Putumayo), therefore, the contingency point did not have risk reduction measures.

What was affected?

According to the monitoring carried out by the ANLA, the following impacts were identified: in the biotic environment, the vegetation, and variations in the hydrobiological communities were affected, in the areas where the hydrocarbon spill was present; in the abiotic environment, impacts to the soil resource/change in the natural physicochemical characteristics and temporary variations in the drainage characteristics in the cleaning work areas; in the socioeconomic environment, hydrocarbons' taste and smell in the fish, and fish mortality, were reported in the area near the point of loss of containment.

What was learned?

- The permanent monitoring of key variables of the prioritized risk scenarios is essential, to identify critical points to intervene for risk reduction.
- The update of risk analyzes of the prioritized risk scenarios is required when the risk monitoring indicates significant variations.
- Based on risk analysis, it is essential to implement risk reduction measures to guarantee safe operation, even when there are critical exogenous conditions.
- Risk management is constant because risk is dynamic.

KEYWORDS

Follow-Up, Monitoring, Reduction, Risk Analysis

Methodology for the Determination of Natech Scenario Vulnerability Indexes to be Included in the Metropolitan Area of the Aburrá Valley Territorial Management

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Aburra Valley includes the municipalities of Barbosa, Girardota, Copacabana, Bello Medellín, Itagüí, Envigado, Caldas, Sabaneta and La Estrella, and is characterized by a large number of installations that manage, store or, in general, handle hazardous chemical substances. It is located in areas susceptible to the occurrence of different natural events such as floods, torrential floods or mass movement, which could affect these facilities and trigger a Natech-type event. In addition to the above, EAFIT University and AMVA, the administrative entity in charge of consolidating the progress and harmonious development of the great Metropolitan Region, have jointly been advancing a project to design a methodology that allows identifying vulnerable areas to Natech scenarios due to flooding, torrential avenue and mass movement phenomena, with a view to proposing measures for their territorial management in the Aburra Valley.

In this sense, a methodology was proposed to determine a Natech risk condition index that was composed both by an industrial hazardous index and by an exposure level around each facility. For the first case, it is an index that contemplates the level of hazard of the installation, in terms of its equipment, hazardous materials, level of vulnerability, and industrial density. The potential level of exposure corresponds to possible affected targets within a given distance, due to the release of a hazardous substance. To this end, information reported in the Land-Use Planning Plan is contemplated, such as the soil classification, its current use and the type of critical or sensitive infrastructure. For this purpose, information available in the chemical risk map (MRQ) was implemented, a tool that has been feeding the AMVA with technical visits and information on the hazardous substances, after a process of identifying key variables that describe the hazard level of each facility evaluated, considering both a component of hazard to each phenomenon, the location of the facilities and the inventory of hazardous chemical substances reported.

This work shows the proposed methodology for calculating the Natech risk condition index, and the results in a pilot test for a certain set of fixed industrial facilities located in the Aburra Valley, which handle or store hazardous substances and are exposed to medium and high hazards either due to mass movements, flooding and/or torrential floods. In terms of the results obtained, a differentiated analysis was made depending on the natural hazard to which the industrial facilities under study are exposed, allowing a differentiated analysis for six different zones of the Aburra Valley, with the aim of supporting decisions regarding risk reduction measures for Natech scenarios triggered by the different natural events analyzed.

KEYWORDS

Hazard Level, Potential Exposure Level, Risk Condition Index, Natech Scenarios, Natural Hazards

2nd session

TSUNAMI NATECH RISK ASSESSMENT

Chair:

AOKI·SHIN-ICHI
Osaka University

JAPAN

The Urgent Need to Carry out Probabilistic Tsunami Hazard Studies in Colombia: Implications for the Port, Fishing and Oil Industry

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Colombia has a clear tsunami hazard on the Colombian Pacific coast, as the events of 1906 and 1979 have shown. For the Colombian Caribbean, the level of tsunami hazard is not so clear. In the last 20 years, different national and international entities have joined efforts to improve the characterization of the Pacific subduction zone as a tsunamigenic source. However, the country's limited historical record does not allow us to know precisely the recurrence and magnitude of tsunami events in the area. Tsunami hazard assessment studies have been developed mainly from the numerical modeling of deterministic scenarios that take the 1979 and 1906 earthquakes as sources. However, the tsunami hazard in probabilistic terms of exceeding certain parameters, such as the maximum distance or height of flooding, within a period of time for specific locations, has not been calculated. This means that there is no quantification of risk, and in turn implies that companies do not have clear information that allows them to estimate the potential consequences of these events or Natech-type events, nor to generate risk reduction measures, or implement financial protection measures (risk transfer) with respect to the tsunami hazard.

In this paper we show the need to carry out such studies in the country, with a focus on the fishing, port and oil industry, since a tsunami event could trigger technological accidents related to these economic activities that take place in ports such as Buenaventura, Cartagena or Tumaco. The March 2011 tsunami in Japan triggered the second largest nuclear accident in human history and dozens of technological accidents. This background, in addition to the impact on the Japanese people, evidenced the need to advance in tsunami risk knowledge and, above all, to have a probabilistic approach with strong scientific support, in which national scientific technical entities and authorities play a determining role, from their competence, in the generation of information and data that allow predictive analysis of the hazardous event to be carried out, on which decisions are made regarding disaster risk management and emergency response.

The presentation will also address the importance of additionally adding the consequence analysis (CA) for technological events, which, in light of what is established in the national regulations and in compliance with corporate policies regarding process safety and HSE management, must be carried out within the framework of the disaster risk management plans, so that the results of these CA, coupled with the analysis of the tsunami hazardous event, allow dealing with events of natural origin that trigger technological events or Natech events.

KEYWORDS

PTHA, Tsunami Hazard, Probabilistic Studies, Technological Risk, Storage of Hazardous Substances

Towards Probabilistic Tsunami-Triggered Oil Spill Fire Hazard Assessment: A Preliminary Uncertainty Analysis

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KEYWORDS

Natech, Tsunami, Oil Spill, Fire, Uncertainty

Tsunami-triggered oil spill fires are a type of emerging cascading disaster and preparedness against the fires is important in the context of natural hazard triggered technological (Natech) disaster risk reduction. In particular, the tsunami after the 2011 Great East Japan earthquake, which triggered large-scale oil spill fires spreading over Kesennuma Bay, Miyagi, have highlighted a critical aspect of the safety of tsunami vertical evacuation structures; that is, how the safety of tsunami vertical evacuation structures should be ensured from the fires. Current disaster risk management in Japan however lacks preparedness against the fires because the quantitative hazard assessment methodology has not been established.

Our previous studies have therefore developed a methodology for simulating the dynamic behavior of tsunami-triggered oil spill fires and quantitatively assessing their hazards, and have applied it to a possible large tsunami event due to an offshore megathrust subduction earthquake. While the previous studies have demonstrated that the developed methodology can provide useful results for understanding how large an area will be exposed to high thermal radiation from the fires and which tsunami vertical evacuation structures will be in danger from the fires, the developed methodology is deterministic and considers only one possible Natech disaster scenario. Uncertainty quantification is essential to promote reasonable decision making for Natech disaster risk management. This study therefore aims to develop a probabilistic methodology for tsunami-triggered oil spill fire hazard assessments that comprehensively considers various uncertainties associated with the assessments. Here, a preliminary analysis is presented that focuses on the uncertainty of the amount of oil spilled due to tsunamis. For this purpose, a physics-based model for tsunami damage to oil storage tanks is developed by considering floating and sliding due to tsunami wave forces as the dominant damage mechanisms, and is integrated with the stochastic tsunami model that generates Monte Carlo samples for tsunami propagation and inundation based on stochastic earthquake source modeling.

A realistic case study is conducted for coastal petrochemical industries along Osaka Bay, Japan, which have over 200 oil storage tanks, by focusing on possible offshore megathrust subduction earthquakes. Detailed data on oil storage tanks used in the case study are collected through a questionnaire survey among the industries, which contain tank locations, weights and diameters, types of liquid stored, legal maximum allowable liquid volumes, and self-regulated maximum and minimum allowable liquid surface heights. The liquid surface height of each oil storage tank, which constantly changes, is considered as a random variable independent of each other, and is assumed to follow a uniform distribution between the self-regulated maximum and minimum allowable liquid surface heights. Three tsunami scenarios corresponding to 10, 50 and 90 percentiles are selected from the 300 tsunami scenarios sampled, and the variability of the total amount of oil spilled is evaluated through 1000 Monte Carlo simulations for each tsunami scenario. The results show that the total amount of oil spilled greatly depends on spatial patterns of oil storage rates as well as tsunami scenarios and this characteristic can significantly influence the behavior of subsequent fires.

Risks Associated with Floating Objects Around Coastal Built Environments During Tsunami

Built environments constructed at the disaster-prone coastal regions around the world consist of business and residential facilities which are commonly exposed to disasters such as typhoons and tsunamis. 2011 great east Japan earthquake induced tsunami showed that various objects like driftwoods, shipping vessels, containers and automobiles interacted with onshore facilities and led to partial or complete damage. Similarly, transport of these objects by the tsunami flow became hindrance to the public during evacuation process also witnessed. Therefore, a need of proper understanding of commonly available objects around the disaster area and the expected outcomes of impacts to the structures and society must be evaluated for the preparedness of future disasters. Hence, this study presents an approach taken to visualize and quantify debris entertainment and induced forces respectively during the tsunami by hydraulic experiments.

Variations of forces with different size of objects as well as dynamics of debris were analyzed. There were additional exerted forces found other than wave only impacts while transport of the debris showed an unaligned behavior with suggestions in technical guidelines.

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KEYWORDS

Tsunami, Debris, Impact, Transport

Oil Spill Simulation Caused by Tsumani and Evaluation of teh Government's Measurements at Osaka Bay

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KEYWORDS

Oil Spill, Tsunami, Nankai-Trough Earthquake, Osaka Prefecture, Tsunami Fire

In 2011, Great East Japan Earthquake caused the oil spill and the tsunami fire. It took nine days to end the fire completely. Currently, Nankai-trough Earthquake is expected to be occurred within 30 years around the Japan island and the same risk as the 2011 earthquake is estimated at Osaka Bay. The Osaka prefecture government takes a measurement for main oil tanks of petrochemical complex and predicts that the amount of oil spill will be decreased by 23000 kL at most. In order to evaluate the effect of measurements, we have conducted two oil diffusion simulations after Nankai-trough earthquake at Osaka Bay using tsunami simulator, STOC, and oil diffusion simulator, STOC_OIL.

The first simulation scenario is for before the measurements and the second one is for after it. Although the amount and the spread of spilled oil was reduced after the measurements, the spilled oil arrived to evacuation buildings pointed by their affiliated cities. At two hours after the earthquake occurred, the first tsunami inundation was observed at petrochemical complex and the oil spill started at that time. At three hours from the earthquake the second wave came and the spilled oil spread in the direction to both the ocean and residential areas including evacuation buildings. The Hokko area which is the northern part of petrochemical complex and be included in Osaka city would have a risk of tsunami fire at evacuation buildings in the downtown. This result indirectly shows the huge damage to the infrastructures and people. The SakaiSenboku area which is the southern part of petrochemical complex has the residential areas and is also expected to have the high density of spilled oil around evacuation buildings that would cause the tsunami fire. Our results indicates that the measurements by the governments might reduce the damage of spilled oil, but there is still high risk of tsunami fire at evacuation buildings.

Risk Assessment of Secondary Disasters by Tsunami Debris in Osaka Bay with Ocean and Inundation Model Considering Meteorological External Forces

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The tsunami generated by the Great East Japan Earthquake damaged urban areas and oil tanks, spilled oil and drifted debris, and finally caused fires on the sea surface. The fires that floated in the sea for several days blocked the evacuation of ships and spread fires themselves to the land, resulting in more damage. In addition, drifting debris sank and accumulated on the seabed, blocked shipping routes, and disturbed the transport of goods to the affected areas.

For drift analysis focusing on the damage caused by tsunami for several hours after the occurrence of a tsunami, it is sufficient to consider only flow generated by the tsunami because it covers discharge and drift processes during the period. However, the currents are also dominated by meteorological and oceanographic external forces such as tides, winds, and freshwater inflow. Therefore, when analyzing the behavior of tsunami debris on a long-term scale, considering the external forces is also necessary. In particular, wind-driven currents and river water flowing into the surface layer are essential for estimating the destination of debris on the sea surface and the location of the fire on the sea.

This study analyzed the behavior of tsunami debris by considering the tsunami and other external forces and verified how the distribution of the area of secondary disaster could change by wind and river flow. We analyzed the behavior of vehicles, oil, and other debris at Osaka Bay in Japan to estimate the risk of fires on the sea surface and blockage of shipping routes under the assumption of inundation caused by the Nankai Trough earthquake. Four patterns of tsunami flow fields with different wind conditions and river flow rates were calculated by SCHISM, a three-dimensional ocean model, to verify the difference in the behavior of drifted debris and the area with secondary disaster risk.

The drift destinations of debris and oil spills were significantly affected by wind conditions and tended to drift downwind. The risk areas by fires on the sea surface correspondingly changed. In particular, the southwesterly wind blew the drifted materials toward the shore and increased the risk of fire to residents and port facilities. On the other hand, the difference in the risk of blockage due to vehicles was found to be negligible because vehicles sink before the effects of external weather forces appear.

This study could summarize that it is necessary to take the effect of external meteorological forces in order to evaluate practical disaster risks into account. The necessity depends on the duration of floating debris.

KEYWORDS

**Tsunami Debris,
Fire on Sea Surface,
Secondary Disaster Risk,
Ocean Model,
Osaka Bay**

3rd session

NATECH RESEARCH: CASE STUDIES IN COLOMBIA

Chair:

ALEXANDER GUZMÁN
Tohoku University

JAPAN

Identification and Analysis of Landslide Events in Hydrocarbon Transmission Pipelines

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The intricate interactions between natural hazards and industrial facilities handling hazardous materials have contributed largely to exacerbate accidental impacts on communities and the environment, especially in urban areas. In mountainous regions all over the world, particularly in tropical areas affected by heavy rainfall periods, landslides represent some of the most frequent natural hazards leading to catastrophic events. When a landslide occurs, the impacts to oil and gas pipelines often result in large leaks, leading to casualties, major impacts to the environment, and long periods of service disruption, causing extensive damage every year. The related hazards are complex, and they require detailed risk assessments, but they also require detailed information about the pipeline and the environment, and this constitutes a difficult task in the risk assessment process. In the last decades, several risk analysis and assessment methodologies have been proposed considering different types of industrial equipment, and for various types of natural hazards including earthquakes, flooding, and lightning. Nevertheless, a Natech risk assessment methodology to consider landslide impacts on oil and gas transmission pipelines is still needed, and one of the first challenges is to define the relevant scenarios.

The aim of the present work is to identify scenarios for events triggered by landslides on pipelines through the analysis of past events. This was carried out using the accidental database from the National Agency for Environmental Licenses (ANLA) from Colombia (a mountainous country with pipelines all over the territory). The database was analyzed to identify potential scenarios to support the risk assessment process. This presentation will describe the results of the database analysis that aimed at identifying causes and consequences of accidents, failure modes and impacts. Some standard parameters were defined for each event, according to environmental properties, pipeline properties (diameter, age), the hazardous materials (gas, crude oil, gasoline) involved, and consequences (impacts on communities, environment, infrastructure). These identified criteria are the initial input for the relevant accident scenarios. The results will be later used in the implementation of hazard identification techniques as part of the development of a Natech risk assessment framework. The main goal is to support decision making and prioritizing of resources to manage accident risks on oil and gas pipelines subject to landslide hazards. This can also contribute to the development of risk reduction measures, and risk management policies to support industrial operators and government entities on their decision-making process involving all stakeholders in the territory (communities, industrial facilities and government).

KEYWORDS

Natech Risk Assessment, Oil and Gas Pipelines, Landslides, Scenario Identification, Past Events Analysis

Multitemporal Evaluation of Community Resilience to Technological Risk Disasters in Commune 10 of the Municipality of Dosquebradas

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KEYWORDS

Community resilience to disasters, technological risk, ARC-D tool, disaster risk management, multi-temporal analysis of resilience, risk perception

The perception of technological events in communities is a fundamental part of understanding disaster risk management. In 2011, in Dosquebradas municipality (Villa Carola neighborhood), a Natech event took place, which caused 33 human losses, as well as physical and material losses, overflowing institutional and community response capacities. This chapter describes the application of the ARC-D tool to measure and assess multi-temporal community resilience to disasters. A methodology with a qualitative approach was applied for community-territory interaction and a quantitative approach for data processing. For the community discussion, a survey-type instrument was used, measured by a focal group with a facilitator, in which four thematic areas were evaluated.

The application of the tool had a previous diagnosis of resilience and a pilot adjustment test to the focus group. A low level of resilience was found in the pre-event (year 2011) with a greater emphasis on the low understanding of risk, contrary to the highest component that corresponds to social cohesion in the territory. The post-event (year 2021) obtained a medium level of resilience with better results in strengthening governance to manage disaster risk, reflected in its outstanding component, which was the participation of women. It is concluded that commune 10 of Dosquebradas improved its community resilience capacities in the face of disasters due to technological risk from 30.08% to 60.18%, highlighting the increase in community participation, social organization and the appropriation of the risk prevention culture. It is recommended that territorial and local authorities know communities' risk perception to adequately focus their policies, strategies, and instruments in decision-making.

Considerations for a More Inclusive National Contingency Plan: Knowledge of Traditional and Non-Traditional Communities

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Managing natural disasters is a growing challenge as outlined in the Sendai Framework (2015-2030). Furthermore, the management of technological disasters is a relevant matter, since it optimizes resources. However, managing NATECH events (Natural Hazard Tiggering Technological Disasters) requires cooperative and interdisciplinary work between the natural and social sciences. Thus, to reduce limitations regarding risk management, not only current scientific knowledge should be considered, but also empirical knowledge derived from traditional communities. In Colombia, approximately 3.4% of the population is indigenous and 10.62% are Afro-descendants, these inhabitants having generational knowledge of the territory. The National Policy for Disaster Risk Management (Law 1523 of 2012) reinforces, through its participatory principle, the valorization of Colombian ethnic communities' traditional knowledge. This Policy frames the National Plan for Disaster Risk Management (Decree 308 of 2016) and this in turn contemplates the updating of the National Contingency Plan (PNC) of 1999.

It was identified that the current 2021 PNC is familiar with the term NATECH and includes it as part of its Operational and Strategic components. However, there is no clear guideline on how to approach NATECHs. In the PNC strategic, operational and information management components, the presence of non-traditional communities is considered as potential victims of the disaster and the inclusion of traditional or local knowledge for the creation of emergency response strategies is scarce. It is understood, as described in the implementation section of the PNC, that public and private companies are the ones who carry out the dissemination and training in the areas of influence of their Emergency and Contingency Plans (PEC).

Thus, the PECs can be considered as the starting point to include traditional or local knowledge. So, how to prevent a natural event of great intensity from causing a mega-disaster when a technological disaster also develops? It should be noted that knowledge of the territory is a strength that traditional communities intrinsically have, and that when applied in disaster management, it reduces a natural disaster's level of impact, and therefore helps to reduce damage of a mega-disaster. However, traditional communities are also the most vulnerable to technological disasters due to their lack of knowledge.

It can be seen that although the PNC is recent, it still faces the challenge of having greater social participation, especially in the inclusion of traditional or local communities. In this way, this callas for the use of interdisciplinary sciences (sociohydrology, sociogeomorphology, ethnogeography) to fill the lack of interconnection in NATECH disaster risk management, mitigation and reduction actions. This analysis serves as a preliminary approach for the future improvement of Colombian public policies by adopting a greater nature of participatory policies based on different knowledge tools.

KEYWORDS

National Contingency Plan, Traditional Communities, Natural Disaster, Technological Disaster, Public Policies

4th session

ADVANCES IN NATECH RISK COMMUNICATION, PERCEPTION, AND EDUCATION

Chair:

SUBHAJYOTI SAMADDAR
Disaster Prevention Research Institute
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A Multiple Perspective on the State of Natech Risk Management

Natural hazards triggered technological accidents which usually involve hazardous-material releases are known as Natech events. As a typical type of such event, the Fukushima nuclear accident posed a threat to the population, the environment and the economy, and reminded the government, researchers, risk managers, and multi-stakeholders to develop a comprehensive framework for managing Natech risk.

With the rise of Natech risk awareness, the governments and policymakers released a series of laws/regulations among different countries, however, not so much effort has been done in understanding whether there existed any differences among those laws/regulations. Therefore, this study summarized and identified those differences based on a systematic review and comparison of the formulated regulations from a global view. This study then analyzed the potential causes why the differences existed and presented possible strategies for closing such gaps, especially in China, including: 1. Promoting public awareness of Natech risk; 2. Identifying responsibilities of Natech risk management; 3.

Establishing databases of Natech events; and 4. Conducting activities of Natech risk education and training. This work could be contributed to understanding what are the states of Natech risk governance from a multi-culture perspective, and helping clarify reasonable solutions on how to integrate ideas from policymakers to develop a normalized framework to manage Natech risk to better achieve the objectives proposed by the Sendai framework.

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KEYWORDS

Natech Risk Management, Natech Risk Governance, Risk Management System, Systematic Review

The Significance of the Internal and External Synergistic Effects in Natech Hazards

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Synergistic effects refer to the phenomenon that hazards mutually interact and influence, resulting in variations in the consequence and risk of the hazards. Due to the existence of the synergistic effects, the development of the process of multi-hazard Natech events becomes unpredictable, and the consequence may become more severe compared to individual hazards. In recent years, the research on synergistic effects become a hot topic of multi-hazard Natech research. Regulations have been issued by administrators, and academic research have been conducted which concentrated on the synergistic effects in Natech hazards. However, previous research failed to reveal the impact of the synergistic effects holistically and in-depth. Most of the research focused on the internal synergistic effects and few research focused on the external synergistic effects between natural hazards and technological accidents.

Corresponding research results cannot fully support the improvement of the risk assessment methods for Natech hazards. Here we constructed a research framework of the internal and external synergistic effects in Natech hazards, aiming to guide the follow-up research on the synergistic effects. The internal synergistic effects among natural hazards, such as floods, earthquakes, and freezing disasters, and among technological accidents, such as fires, explosions, and toxic releases, were analysed. More importantly, the external synergistic effects between natural hazards and technological accidents were also analysed and displayed in the framework. Quantitative analyses of the synergistic effects were also conducted based on experiments and numerical simulations. The internal synergistic effects among fires, explosions, and toxic releases were quantitatively studied by the experiments on a fire-explosion coupling experimental platform. The external synergistic effects between natural hazards—high winds and wildfires—and technological accidents were studied by numerical simulations. Our results demonstrated that the internal and external synergistic effects can significantly influence the consequence and risk of Natech hazards, indicating the significance and necessity of the research on the synergistic effects. We anticipate our research framework to be an instructive guidance for subsequent research on the synergistic effects in Natech hazards.

The quantitative research results on internal and external synergistic effects can be practically valuable for the improvement and optimization of the risk assessment methods for Natech hazards. It is also expected that our research results can provide reference and guidance for risk management, loss prevention, land-use planning, and development strategy in industries involving hazardous materials.

KEYWORDS

Natech Hazards, Synergistic Effects, Risk Assessment, Numerical Simulation, Loss Prevention

A Serious Gaming Approach for Natech Risk Awareness and Chemical Information Disclosure

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Disaster risk management researchers and practitioners have underscored the important role community engagement plays in the increasingly complex setting of disaster risk reduction. Nonetheless, despite calls and efforts from international organisations, a gap between research and implementation is still evident. Risk communication is essential for enhancing community preparedness against disasters, particularly concerning events that involve the release of hazardous chemicals, such as technological accidents triggered by natural hazards (otherwise referred to as Natech).

Equally important, risk communication practices founded on transparency and information disclosure allow risk-informed choices and fosters stakeholder participation overall. Recently, serious gaming approaches (i.e., games developed for educational purposes and not only entertainment) have gained substantial recognition in the area of disaster risk management as potential participatory tools that effectively promote public awareness about hazards and vulnerabilities, and support decision-making for risk-related issues. Aligning with the current risk communication paradigm which promotes participatory approaches that extend the disaster risk management discourse to involve the public, this research explored the potential of serious gaming for Natech risk communication. This study proposed and developed EGNARIA: a novel, educational, role-playing board game considering earthquake and tsunami scenarios that might cause subsequent chemical accidents. Players try to survive by taking disaster preparedness actions and responding correspondingly to the natural and chemical hazards they face. The game is designed to raise community awareness about Natech, and generate a discussion among stakeholders about risk management strategies, chemical information disclosure and risk-informed decision-making concerning Natech accidents. In order to assess the impact of the game a quasi-experimental design was employed with a questionnaire survey before and after the trial application with Kyoto University (Japan) affiliates. In order to understand the game's impact on the participants' communication behaviour regarding Natech risk, the survey was structured based on measures from the interpretative framework of the Situational Theory of Problem Solving (STOPS).

The preliminary findings from the game trial suggest an overall positive reception from participants as an engaging, educational tool to introduce communities to Natech accident risk and discuss about its management. Participants noted that the game raised their awareness about Natech accidents, highlighted the importance of community participation and chemical information disclosure, and positively affected their intentions to actively search for and share information about Natech risk. Implications for Natech risk communication are discussed.

KEYWORDS

Natech, Risk Communication, Risk Information Disclosure, Disaster Risk Management, Serious Gaming

Inequality to Natech Resilience: Social Dimensions in Natech Vulnerability Analysis

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While studies on natech in Thailand are in its early stage, quite a few industrial facilities are sited on low lying deltas under pressure to floods and their systemic impacts from combined natural hazards and technological accidents. Similar to many other global south industrial zones, these facilities are often surrounded by relatively low-income communities and urban poor who are among those at frontiers exposing to such impacts.

This kind of socio-technical context adds to the complexity in handling natech vulnerability and urges the needs for input from wide range of disciplinary perspectives. In responding to this call, the paper aims to help expand understanding of natech vulnerability from social perspectives by drawing on inequality framework together with vulnerability analysis and the concept of equitable resilience. In doing so, a case study approach is applied toward communities around an industrial estate located on the south-east of Bangkok in which fieldwork, interviews, Delphi techniques and policy reviews are among data collection techniques.

Results reveal interconnected dimensions of inequality in relation to Natech risk found in this context, providing basis for discussions on ways forward to achieve the more just Natech management.

KEYWORDS

Social Inequality, Natech, Vulnerability, Equitable Resilience, Thailand

Expanding the Natech Horizon by Considering Implementation: Why an Aluminum Factory Explosion was a Surprise to the Local Community

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A great accomplishment of the Natech community was that it looked beyond the barriers that kept the analysis of natural hazards separate from technological hazards. We hope to encourage discussion that might lead to a further expansion of the Natech perspective. Our starting example is a small but serious Natech disaster.

On 6 July 2018, triggered by torrential rain and flooding, a small local aluminum plant exploded in Soja City, Okayama Prefecture, Japan. The explosion caused extensive damage to the neighboring community, making it a representative 'Natech' disaster. While the plant had been operating for decades, the explosion, or to be exact, the risk of a flooding triggered explosion, came as a major surprise to the neighboring community.

Why was the disaster such a surprise? We describe a complex of reasons. They represent significant challenges to the management and governance of Natech (and other) hazards. To date these challenges have not been adequately studied or confronted and they merit more Natech attention. As we have discussed in previous Natech conferences, there is a need for "communicative spaces" in meeting such challenges. Communicative spaces support constructive collaboration. In the aluminum plant disaster, there were deficiencies in awareness of hazard potential, no communication of community concerns and knowledge, and lost opportunities for collaborative disaster management. We go on to suggest that Natech would benefit from paying more attention to "implementation science". Of particular salience are questions about the nature of the vigilance that is needed for hazard management and governance and questions about how such vigilance can be maintained.

The four authors offer a variety of perspectives, and we hope that there will be a broader discussion from conference attendees.

KEYWORDS

Natech, Risk Governance, Implementation, Vigilance, Communicative Spaces

5th session

NATECH RISK FACTORS MODELING

Chair:

GUOYI HAN
Stockholm Environment Institute
SWEDEN

Asset Performance Management Focusing on Geohazard Analysis

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Within the framework of CENIT's Asset Performance Management, there is a Geohazard Management strategy. This strategy is executed in a systematic and continuous manner, and is based on Base Processes that are the starting point in the Management and Analysis of Inspections and Monitoring, in the Condition Analysis, and in the Planning and Verification of actions required, so that there is a timely identification of the development of physical processes (e.g. rains and earthquakes), morphodynamics, and anthropic activity (i.e., urban expansion in mountainous terrain, mining activity, deforestation), which can influence the stability of the rights of way (DDV) and eventually in the pipelines' integrity. These elements, in monitoring the condition of the Asset, are intertwined with the implementation of artificial intelligence techniques with supervised learning algorithms for the spatial and temporal definition of the effect of hydrometeorological phenomena on the stability of the rights of way.

Likewise, CENIT's strategy considers vulnerability criteria of the exposed element (the pipeline) in the face of the materialization of geohazards, which allows evaluating and updating the hazard and risk levels of its infrastructure not only from the implementation of conventional inspection methods and geotechnical monitoring, but through the analysis of internal pipeline inspections, applied to the identification of instability processes and their interaction with the infrastructure.

In this way, a strategy has been consolidated that has made it possible to generate a sustained reduction trend over time in integrity failures due to geohazards, since: it allows the integration of information from different disciplines based on the environmental conditions where the operation is carried out, relates contributing factors and triggers of geohazards in their interaction with the infrastructure, and prioritizes spatially and temporally maintenance plans.

KEYWORDS

Geohazards, Natech, Risk, Performance Management, Artificial Intelligence

An Innovative Accident Paradigm to Support a Comprehensive Natech Risk Assessment

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KEYWORDS

Natech, Risk Assessment, Accident Paradigm, Indirect Scenarios, Systemic Failure

The interaction between natural hazards and technological installations can produce complex cascading events involving hazardous materials which are termed Natech accidents. Climate change and the possibly increasing vulnerability of industrial facilities caused a growing concern towards Natech hazards in the last decades. The majority of currently available methodologies addressing the identification of Natech scenarios and the quantification of the related risk metrics consider only the possibility of direct damage of process and storage equipment caused by natural hazards.

Nevertheless, recent severe Natech events as the Fukushima disaster (2011) and the Arkema accident (2017) demonstrated that the direct failure of equipment is not the sole possible accident trigger. Indeed, in the aforementioned accidents the event sequence was initiated by the impairment of auxiliary systems and utilities induced by the natural event. This in turn led to the impossibility of keeping unstable substances under safe conditions and eventually, given the concurrent depletion of additional safety measures, to extremely severe scenarios. Such complex accident sequence falls outside of the capabilities of current Natech risk assessment methodologies, which are mostly limited to the identification and assessment of scenarios caused by the release of hazardous materials due to the structural damage of main equipment. The present contribution is aimed at presenting an innovative comprehensive approach to the identification of Natech scenarios and to the quantitative assessment of Natech risk.

The approach addresses the identification of both direct and indirect Natech scenarios and considers the possible unavailability of utilities in accident progression and in the escalation of accident consequences. The framework constitutes a preliminary attempt for the development of specific strategies for the identification of alternative routes leading to Natech events, considering that loss of containment can be caused either by the direct damage of equipment or by the failure of utility systems and of safety measures. Overall, the approach paves the way for a better description of the complex cascading nature of Natech events and fosters the development of more effective risk management strategies.

How We Assess the Natech Risk Under a Changing Climate?

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Natural hazards could affect the industrial region and caused chemical-related equipment failure, which involves hazardous materials release accidents (as known as Natech). Theoretical speaking, any type of natural hazard could trigger Natech events, such as the Fukushima nuclear accident. But hydrometeorological-related hazards seem to be more prone to triggering such terrible events in the past decades due to climate change. Many experts in the area of Natech risk management had pointed out that all the stakeholders should not ignore the effects of climate change on the occurrence of Natech events.

However, not so many effective Natech risk assessment methodologies were developed to assess Natech risk under a changing climate from a large-scale perspective. Aimed at filling that gap, a geographic information science-based methodology was proposed in this study to analyze the probability of tropical storm-related Natech events in the eastern side of the United States. The results suggest that the probability of tropical storm-related Natech events is increasing in the study area and there is more uncertainty in the change of Natech occurrence probability. This work is the preliminary work on the development of the Natech risk assessment method by considering climate change from a large-scale view, but we also present a prototype and improved model based on deep learning methods.

This work is expected to contribute to the risk tracking and assessment of hydrometeorological-related Natech events and provide useful information to decision-makers to develop Natech risk reduction strategies.

KEYWORDS

Natech, Climate Change, Risk Assessment, Spatial-Temporal Variation, Fragility Analysis

Analyzing the Fate of Hazardous Materials Released in Floodwater

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KEYWORDS

Flood, Dispersion, Consequence Analysis, Modelling, Pollutants

In case of flood impacts on chemical installations materials, accidental releases of hazardous materials, followed by pollution, fires or explosions, can occur. Accidents that involve the release of hazardous materials due to natural hazards, like floods, are called Natech accidents.

During flood-triggered Natech events, secondary containments (e.g. in dikes around storage tanks) are often incapable of retaining releases of hazardous materials. Instead, chemicals can enter the floodwaters and with it disperse over vast areas, potentially contaminating urban settlements, rural areas, and water bodies. Addressing this problem is complex and requires specific knowledge, the right set of tools, and proper preparation.

Although the dispersion of pollutants in water bodies (e.g., rivers and seas) is a well-addressed scientific topic, there is little to no knowledge about dispersion of pollutants carried by floodwaters. There is therefore a need for dedicated studies on the topic of hazardous substance dispersion in and with floodwater, as well as inclusion of (an) adequate model(s) in Natech risk analysis systems and tools to improve the management of flood-triggered Natech risks.

This study aimed to address this gap and explore the feasibility of implementing oil and chemical spill models into the JRC's RAPID-N system for rapid Natech risk assessment and mapping.

An analysis of the scientific literature to identify models adequate for describing the dispersion of hazardous materials (toxic and/or flammable) in floodwaters was carried out. Suitable model(s) for pollutant dispersion in waterbodies were identified. Ranking criteria were made that allowed to shortlist a group of models that were considered fit for integration into RAPID-N. As a result of the selection process, it was decided to model the fate of substances in floodwaters with OpenDrift/OpenOil. A proof-of-concept to demonstrate the workflow was also provided, with the area of study being located in northern Portugal, on Tâmega watershed/river, near Chaves, where 2D hydrological data from previous design flood simulations were available. Lastly, the study concludes with a discussion of identified gaps related to dispersion of substances in floodwaters and recommendations on how to close them.


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6th session

NATECH RISK AND EMERGENCY RESPONSE IN COLOMBIA

Chair:

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An Overview of Natech Risks in Colombia

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The geographical location of Colombia makes it a country prone to different types of natural hazards, including geological and hydrometeorological hazards. In addition, given the presence of fixed and distributed industrial facilities in the country, technological risks, considered phenomena derived from human activities, including industrial, extractive and transportation activities, among others, are also present in the territory. From this perspective, it is important to identify the main natural phenomena that can directly impact industrial facilities in the country and affect both neighboring communities and ecosystems. Therefore, the identification of events of natural origin that trigger technological accidents and that involve the release of hazardous materials, called Natech, and their possible impact on industrialized areas that process, handle, store or transport hazardous substances is of great interest to Colombia. Natechs are considered low-probability events, but the effects in large areas and the magnitude of their consequences have shown that they represent a high threat to society. This is due to the fact that the release of hazardous materials can give rise to scenarios of fire, explosion, toxic clouds and contamination of ecosystems, generating intense, serious and widespread effects on the territories.

Colombia has regulatory mechanisms that conceive Natech risk as an important scenario in the country's management systems, as is the case of Decree 2157, promoting the development of strategies to analyze risk levels and especially the implications of natural hazards in the safety of their territories. However, guidelines still need to be developed to strengthen Natech risk management in the country. This evidently must start with a characterization of Natech scenarios in Colombia, for which this study is developed. This is a work in progress that seeks to identify the departments and municipalities of Colombia that are most vulnerable to the materialization of Natech events, to prioritize the implementation of risk reduction measures and carry out detailed analyzes in high-hazard areas. Likewise, it seeks to be a reference for Disaster Risk Management Plans, which within the framework of territorial development must identify and characterize the present and future risk scenarios in the territory, so that this Natech risk panorama with a prospective vision, seeks to strengthen risk reduction mechanisms both at the industrial and territorial levels in Colombia.

KEYWORDS

Disaster Risk Management, Natech, Risk Reduction, Risk Identification

Disaster Management and Emergency Response in the Natech Context: The Case of the Municipality of Facatativa

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KEYWORDS

Emergency Management, Emergency Response, Hydrocarbons, Water Tributaries, Facatativá

In February 2021, a call is received from the rural community of the municipality of Facatativa, warning of the presence of strong odors of possible hydrocarbons in the area surrounding the Los Andes River, at Los Manzanos village, a situation that is addressed immediately by the Volunteer Fire Department and informed to the Municipal Risk Management Council, who, following the general response established in the Municipal Emergency Response Strategy, activated the response and support protocol through their Coordination, also informing the hydrocarbon transport and logistics company, the environmental authority and other relevant entities to actuate according to the responsibilities within the response protocol framework.

Subsequently, after confirming the impact on one of the transport conduits on the tributary, the different immediate actions for disaster risk reduction and mitigation are coordinated and articulated between public and private entities, as well as the emergency response and the consequences derived from the incident, such as water rationing, public order problems, and the subsequent declaration of a Red Alert from the company that provides the public aqueduct service and the municipality of Facatativa, as a preventive measure against the possible presence of hydrocarbons in the reservoirs and infrastructure for the treatment of drinking water for the consumption of the municipality's inhabitants.

Addressing the situation in the ensuing days requires coordinated and harmonized action within the framework of the Incident Command System of municipal and departmental authorities, the hydrocarbon transport and logistics company, environmental authorities, service companies, emergency response agencies, public force, among others, prioritizing the supply of the precious liquid to the community for their basic needs, sampling and monitoring for the detection of hazmat substances in the supply sources, the cleaning of water tributaries, among other actions, which consequently contributed to overcoming the Red Alert and the emergency that originated it.

Guidelines of the National Navy for Emergency Response to Spills of Noxious Substances

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KEYWORDS

Emergencies at sea, Anthropic risks, offshore

The National Navy must act as the first responder with its units deployed in the area of operations; For this, it is essential that beyond their constitutional mission, they know the procedures in case of spills of harmful substances in marine waters, including hydrocarbons, and the inter-institutional work for compliance with the National Contingency Plan, incorporating their dependence on the General Maritime Directorate DIMAR.

On the other hand, a series of risks associated with this activity are projected on the coastal area whose extension is 3,189 km, where the main port, fishing and human settlement activities are carried out with a vulnerability that reaches 4,000,000 people; This must be consistent with the incorporation of the Rio Treaty and the Hyogo framework, where international guidelines were established in the appreciation of environmental dynamics, promoting not only a commitment to caring for the environment, but also generating abilities and skills to counteract hazards of anthropogenic events from the perspective of the operational procedures of naval operations not related to war.

Due to the foregoing and taking into account that the National Navy currently does not have a protocol for dealing with this type of emergencies, the mishandling of these risk scenarios could result in an impact to its naval fleet deployed in the Caribbean Sea, that is, effects on 60% of its units; and the coastal populations that, according to the national simulation of Offshore operations carried out in April 2012, it was concluded that the non-compliance and development of the protocols in a single displaced platform will have regional impacts in the maritime waters of Panama and Costa Rica.

7th session

NATECH RISK IN HAZARDOUS MATERIALS TRANSMISSION PIPELINES

Chair:

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Developing a Simplified Model for Assessing the Pipeline Failure Probability due to Multiple Independent Sources of Rainfall-Induced Debris Flow

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Debris flows, which are fast-moving landslides, have caused damage to oil and gas transportation pipelines. Long-distance oil and gas transportation pipelines passing through certain high-risk mountain areas can be at risk from debris flows. When this happens, natural hazard triggered technological accidents, known as Natechs, may occur (Krausmann et al 2017). Moreover, considering the increasing trend in the number of extreme precipitation events due to climate change, rainfall-induced debris flows—as one of most frequent rainfall-induced natural hazards—are expected to become more common. Hence, Natech accidents involving the impact of debris flow on pipelines are also expected to occur more frequently. Current research methodologies are technically limited to assuming only one initial source for each debris flow. In reality, however, there may be multiple sources that lead to one debris flow (Ciurleo, M. et al 2021)

The uncertainty inherent in the risk assessment process makes the location and number of debris flows difficult to estimate precisely, which in turn leads to numerous debris flow scenarios being taken into consideration. This presents a great challenge in accurately assessing pipeline hotspots for rainfall-induced debris flows. The aim of the current study is to develop a simplified model for estimating the pipeline failure probability due to debris flow from multiple independent sources. In this study, we combined a Monte Carlo method with the Green-Ampt rain infiltration model to obtain the probability of debris flow sources, which can be integrated with a debris flow simulation model and pipeline failure model. Thus, the probability of the pipeline failure can be obtained. The results of the preliminary trial through the methodology will be presented.

KEYWORDS

Multiple Independent Sources, Rain Infiltration Model, Probability of Pipeline Failure

Assessment of Failure Frequencies of Pipelines Caused by Earthquakes in Natech Framework

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KEYWORDS

Natech, Risk Assessment, Earthquake, Pipeline, Fragility Model

Earthquakes can cause severe damage to pipelines triggering major accidents involving hazardous materials as fires, explosions and toxic releases. Such cascading events are called Natech scenarios and can feature severe consequences directly affecting humans or the surrounding environment. The possibility to quantify the risk due to Natech accidents is crucial to manage the related risk and develop effective mitigation strategies. In recent years, a relevant effort was dedicated to the development of an approach able to integrate Natech scenarios into quantitative risk assessment (QRA) approaches. An essential element to enable the Natech QRA is the availability of vulnerability models to correlate the intensity of the natural event with the structural damage expressed in terms of failure probability when the pipeline segment considered is subjected to the natural event.

This contribution is aimed at assessing the suitability of vulnerability models published so far to perform the QRA of Natech scenarios from pipelines due to earthquakes. Indeed, in the available models, the natural event intensity is generally expressed by a limited number of parameters (for instance, in the case of earthquakes, the peak ground acceleration or the peak ground velocity are used as seismic intensity parameter to feed most of the simplified vulnerability models available), while their output can be expressed through two main types of parameters, clearly distinguishing two specific subcategories of models. The first typology proposes the repair rate as performance indicator for the damage of pipeline due to the earthquake, and thus gives as output the numbers of repairs per unit length of pipeline. The second typology of models, on the contrary, proposes fragility curves associated with risk states depending on the mechanism of ground failure. The latter have the important advantage in the framework of Natech risk assessment of having defined the risk status (and thus the extent of the release) with which they are associated.

The available models are applied to case studies and, subsequently, their output is compared to discuss their strengths and weaknesses. Finally, a subset of vulnerability models deemed more appropriate to be applied in the framework of Natech risk assessment is distilled, and their application to the assessment of the expected frequencies of loss of containment events due to pipeline damage is provided.

What Have we Advanced in Natech Approaches in Pipelines?

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The transportation of hydrocarbons has historically been enhanced by pipelines, either underground or on the surface. These lines have the possibility of covering routes of up to 4,700 km (Eastern Siberia-Pacific Ocean Pipeline), they have advantages such as continuous transport and a low failure rate compared to other means of road or rail transport. The routes covered by these pipes, cross different types of soil, water corridors and areas of high consequence, in the case of an accidental event. Also, they are exposed to the occurrence of different events of natural origin, such as those typical of seismic loads, mass movement, and even flash floods, as can be evidenced in accidental databases in the United States (PHMSA) and Europe (EGIG), with about 10% of the records of loss of containment of the transported material. These events can trigger technological events such as fires, explosions or contamination of soil, water or air sources given the hazardous properties of the materials being transported (i.e., flammable, explosive or eco-toxic).

The combination of the event of natural origin, the release of hazardous material and the triggering of a technological event is known as a Natech risk (for its acronym in English: Natural Hazard Triggering Technological Disasters). Recognizing this scenario, different authors have made advances that involve the event of natural origin, how it interacts with the pipeline and which are the failure modes of the system. For example, in the case of a seismic event, it starts from the soil deformation that can be transitory, as in the case of seismic wave propagation, or permanent, as in landslides, faults or soil liquefaction events. From the epicenter of the seismic activity, there is a process of attenuation of the shock waves with distance, which usually considers representative parameters (i.e., PGA, PGV, Arias Intensity), which, in turn, have been used to build deterministic approaches by fragility curves and pipeline repair rates. There are other probabilistic approaches that cover the uncertainty of the physical phenomenon, the interaction with the environment, such as ground stability, and estimate the probability of the system failing. Finally, there are some approaches from a more mechanical aspect that involve finite element simulations (FEM) from a stress perspective. This paper presents a general review of these advances in the face of hazards from seismic activity and mass movement.

It likewise presents a proposal made by the authors when a corrosion process is also contemplated that reduces the thickness of the pipe wall and makes it more vulnerable to failure. Contemplating this type of Natech risks in Colombia is a necessity as it is a country with different natural hazards, not only geological, which can significantly affect people, the environment and business continuity.

KEYWORDS

Transmission Lines, Seismic Activity, Mass Movement, Natech, Review

8th session

METHODOLOGIES AND TOOLS FOR HOLISTIC, SYSTEMIC, AND CASCADING RISK ANALYSIS

Chair:
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The Synergy of Vegetation and Meteorological Conditions Affecting the Norwegian Power Grid: An Example of Natech Risk Influencing Factor

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One of the main vulnerabilities of power grids is towards vegetation. Vegetation can affect a power grid in case a branch or an entire tree falls directly on a power line, or in case it grows under a line, making contact and creating an outage. In addition, climate change is rapidly increasing the frequency of extreme meteorological conditions, which can magnify the effect of these events. This is confirmed by the fact that vegetation was the number one cause of outage in Norway in 2018 and today it is a main contributing factor for outages in power grids in general. While, in some cases, these events can result in only a power loss, the synergy of vegetation and exceptional weather has the potential to lead to wildfires, large blackouts and other related consequences.

The Natech accident at the Arkema plant in Crosby (Texas, US) during the Hurricane Harvey showed what a power outage can cause during extreme meteorological events. Even though we cannot point at vegetation as a direct cause of potential Natech events, there is not doubt that it is a factor influencing its frequency/probability, thus a risk influencing factor. This work focuses on the Norwegian power grid and suggests a risk-based decision support providing grid operators with the possibility to optimize decision-making for vegetation management. With an indication of vulnerable areas and their risk levels, operators can prioritize crucial operations and send teams for clear-cutting the area before a damage is reported, postponing in parallel non-urgent inspection missions.

In addition, they will be able to spot areas more likely to be affected by vegetation-related outages when disturbances are observed. This will not only allow gaining precious minutes in the power grid restauration, but it will also support overall measures for Natech prevention.

KEYWORDS

Power Grid, Vegetation, Inspection, Risk Influencing Factor, Natech Prevention

Safety Distances to Avoid Natech Accidents Caused by Wildfires in the Wild-Industrial-Interface

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KEYWORDS

Natech Accidents, Safety Distances, Major Accident Hazard, Wild-Industrial Interface, Storage Tanks

Wildfires are uncontrolled fires developing from the combustion of wild vegetation. The lengthening of dry seasons and the increasing frequency of heatwaves due to climate change and global warming are favouring the conditions for the development and spread of wildfire events around the world. As evidence, a multitude of extreme wildfires occurred in recent years, such as those developed in Mediterranean Europe (Portugal in 2017 and Greece in 2018), Australia (2018 and 2019), and California (2020 and 2021). Population living at the Wildland-Urban Interface (WUI) and industrial facilities located in the proximity of Wildland-Industrial Interface (WII) can suffer a serious threat when wildfire events occur. Moreover, the fast industrialization, as well as the rapid urbanization of rural areas, are raising concern about the wildfire issue as they increase the extension of the WUI and WII.

The heat radiation generated by wildfires can affect industrial installations located in the proximity of the plant boundary. These equipment items are typically storage tanks, which are characterized by a high structural vulnerability and a huge quantity of hazardous material stored. When damaged by the wildfire, these items can lead to a major accident (fire, explosion, toxic gas dispersion, …), causing an escalation of the consequences. Thus, the provision of adequate clearance areas around the industrial installation is paramount to avoid the spreading of wildfire inside the industrial site.

In the current contribution, a methodology for the calculation of safety distances between the wild vegetation and the industrial site is presented. The methodology accounts for the characterization of the wildfire considering the flame geometry, the flame emissive power and the residence time. The vulnerability of equipment items is evaluated using specific models for the assessment of the storage tanks response to fire exposure. Safety distances resulting from the methodology are then compared with those recommended by current regulations and guidelines. Moreover, since changes in the plant layout are difficult when the plant is already built, the methodology is tailored to account also the implementation of safety measures (such as walls and sprinkler systems) aimed at protecting the tank. Eventually, the methodology is applied to a case study to demonstrate its applicability.

Natech Accident Monitoring and Risk Analysis Using Database

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Natech accidents are considered as accidents at various technological facilities triggered by the impact of natural hazards with releases of chemical substances hazardous to the environment. In this study capabilities are investigated, which propose databases for monitoring of Natech accidents and risk assessment. As a case study, the author's database is analysed that includes information about technological accidents in Russia since 1991. Only open sources of information are used to collect the data.

Currently, the database contains more than 25 thousand units of information. About 12% of recorded events were triggered by natural hazards. The most part of these accidents were infrastructure damages, such as disruptions of overhead power lines and lines of communication or traffic disruptions due to natural hazards and adverse weather. Natech accidents make up the very small part of events. However, they cause large social and environmental damage that should be taken into account in the risk analysis. The database makes it possible to monitor Natech events, to reveal and understand their factors, to trace their development in the time and space context.

Statistical analysis of database information can be used to assess risks of Natech accidents at different territorial levels.

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