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Risk Assessment for Natural-Hazard Impact on Hazardous Chemical Installations

Workshop Outcome Report

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Title Risk Assessment for Natural-Hazard Impact on Hazardous Chemical Installations

Abstract
The impact of natural hazards on hazardous installations can cause major chemical accidents. This so-called "Natech" risk is increasing due to industrialisation and climate change. Capacity building in EU Member States, Candidate Countries and EU Neighbourhood Countries on Natech risk assessment is required for effective Natech risk reduction.

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Executive summary

The impact of natural hazards on hazardous installations can cause major chemical accidents with severe secondary consequences on the population, the environment and the regional, national or sometimes even global economy. This so-called “Natech” risk is increasing due to more industrialisation, climate change, and community encroachment on natural-hazard zones.

In order to support new EU Member States and Candidate Countries in the implementation of the EU acquis communautaire related to risk assessment for chemical-accident prevention and preparedness, as well as EU Neighbourhood Countries in building capacity in this field, the European Commission’s Joint Research Centre organised a training workshop on Natech risk assessment and risk reduction on 16-17 March, 2016. This workshop was organised through the JRC’s Enlargement and Integration Action Programme 2015.

The workshop showed that the participating countries are experiencing the same difficulties related to Natech risk reduction as EU and OECD countries:

1. The Natech risk in some countries may be very high, as many countries are subject to natural hazards and hazardous industries are located in natural-hazard prone areas.
2. Some countries have already experienced Natech accidents in their territory. In addition, the threat of a cross-boundary Natech accident is a high concern for some countries.
3. Frameworks for chemical-accident prevention and preparedness exist, but Natech risks are rarely considered.
4. In many cases, competences associated to chemical accident and Natech risk reduction are distributed across different ministries and require good coordination between ministries to achieve maximum effectiveness.
5. Countries expressed a strong need for Natech risk-assessment methodologies and tools, guidance on Natech risk reduction, Natech risk mapping, early warning systems, and awareness raising and training.
6. Several countries are interested in mitigation and response strategies when there are also impacts on infrastructure from natural disasters that could hinder the response to the Natech event or exacerbate its effects.
7. Several countries indicated a need to apply land-use planning and defensive measures to reduce vulnerability to Natech accidents.
8. A number of countries mentioned a need to purchase equipment to help with response to a Natech event.

The feedback of the workshop participants on the two days of the training was very positive, with a strong interest shown in risk assessment in general, Natech risk assessment in particular, and in learning about the JRC’s RAPID-N tool for rapid Natech risk assessment and mapping, and its capabilities. This indicates a strong interest in risk assessment as a process to increase industrial safety, and in the available associated support tools. The JRC will continue the development of RAPID-N, with the deployment of a prototype for flood Natech risk assessment planned for autumn 2017, and it will continue to offer training courses on the subject. These courses can be held as bilateral training workshops in the requesting country or, if preferred, at the JRC.

1 Introduction

The impact of natural hazards on hazardous installations has caused major chemical accidents worldwide with severe secondary consequences on the population, the natural and built environment and the regional, national or sometimes even global economy via direct and indirect losses, supply-chain disruptions and price hikes. This so-called "Natech" risk[1] is increasing due to more industrialisation, climate change, and community encroachment on natural-hazard zones. This has been recognized in a recent amendment of the European Union's Seveso Directive in which the need to protect against Natech risks has been rendered explicit. However, there is a lack of methodologies and tools to help countries identify Natech hotspots in their territory and to assess and mitigate the associated risk levels[2].

In order to support new EU Member States and Candidate Countries in the implementation of the EU acquis communautaire related to risk assessment for chemical-accident prevention and preparedness, as well as EU Neighbourhood Countries in building capacity in this field, the Natech project at the European Commission's Joint Research Centre (JRC) organised a training workshop on "Risk Assessment for Natural-Hazard Impact on Hazardous Chemical Installations" on 16-17 March, 2016. The objectives of the workshop were:

1. Introduce different risk assessment approaches and familiarize the participants with the concept of Natech risk;
2. Present the JRC's RAPID-N framework for rapid Natech risk assessment and mapping and demonstrate its use for screening for Natech risk hot spots in countries and regions by providing hands-on training;
3. Build capacity in identifying, preventing and preparing for Natech risks on specific sites and across a geographic area.

This workshop was organised through the JRC's Enlargement and Integration Action Programme 2015 in the frame of which the JRC offers specialized workshops and advanced training courses within its area of competence. These workshops are established to allow competent organizations in in the new Member States, Candidate Countries, Potential Candidate Countries, Horizon 2020 Associated Countries, and European Neighbourhood Policy Countries to study the scientific and technical methods and techniques underpinning EU policy implementation. Several representatives from EU Member States (Czech Republic, Estonia, Hungary, Malta, and The Netherlands) also attended the capabity-building workshop.

This workshop also supported the goals of the project "Seveso Capacity Building in EU Neighbourhood Countries" under the direction of the European Commission's Directorate General for Humanitarian Aid and Civil Protection (DG ECHO) and implemented by the Major Accident Hazards Bureau (MAHB) on behalf of DG ECHO.

[1] Natech: **Na**tural-hazard triggered **tech**nological accident

[2] E. Krausmann, A.M. Cruz, E. Salzano (2017) Natech risk assessment and management – Reducing the risk of natural-hazard impact on hazardous installations, Elsevier, Amsterdam.

2 Natech risk assessment, risk reduction and mapping

The objective of this training workshop was to demonstrate the importance of risk assessment as a tool to augment industrial-safety levels by improving the risk management at hazardous chemical installations. It included an introductory module to familiarize the workshop participants with basic risk concepts and the different approaches to industrial risk assessment. The training workshop also provided an overview of natural-hazard induced equipment failure modes and their consequences, available risk-reduction measures for selected natural hazards based on lessons learned from accident analysis, and it highlighted the potential pitfalls in Natech risk management.

The second module of the training workshop introduced the procedure for Natech risk assessment, and the JRC's RAPID-N tool for rapid Natech risk assessment and mapping. The participants were guided step by step through an earthquake case study with RAPID-N and then worked on their own test case. The training also addressed the interpretation of RAPID-N's results for further use in land-use and emergency planning, as well as for Natech damage assessment.

2.1 Natech risk assessment and reduction

The workshop started with an introduction of the definition of "Natech accident" to make sure that participants had a common understanding of the term. For the purpose of this workshop, a *Natech accident was defined as a chemical accident caused by a natural hazard, such as a flood, earthquake, landslide etc*. In this context, chemical accidents include accidental oil and chemical spills, gas releases, and fires or explosions involving hazardous substances from fixed establishments (e.g. petrochemical, pharmaceutical, pesticide, storage depots) and oil and gas pipelines. This was followed by examples of recent major Natech accidents, an introduction of the characteristics of Natech events and the challenges they pose in terms of prevention, preparedness and response, and the current Natech risk-reduction situation based on a survey of EU and OECD countries[3]. The key messages from the first presentation are:

- Industrial accidents caused by natural disasters can create major secondary disasters that can affect the population, the environment, the economy and the supply chain.
- Natech risk is a risk class of global relevance and requires a targeted risk-management approach.
- Natech risk reduction is hampered by the scarcity of methodologies and tools to analyze and map Natech risk, and a lack of guidance on Natech risk management.
- Natech risk is expected to increase in the future due to the presence of more hazards (both natural and technological) and the increasing vulnerability of society.

The second training slot introduced the workshop participants to the most common Natech damage mechanisms, presented selected lessons learned from the analysis of Natech accidents caused by earthquakes, floods, lightning and low temperatures, and provided examples of measures to protect hazardous installations against impacts by these natural hazards. In this context, the JRC's eNATECH database, a repository on Natech accident and near miss data, was presented. The structure of this database is unique in that it was specifically designed for the collection and analysis of Natech events with their distinctive features. The eNATECH database is a public database which can be accessed at: http://enatech.jrc.ec.europa.eu. The key messages from this session are:

- The chemical industry is vulnerable to natural-hazard impact but this is not always recognized.

[3] E. Krausmann, D. Baranzini (2012) Natech risk reduction in the European Union, Journal of Risk Research 15(8), 1027.

- The most vulnerable equipment type are atmospheric storage tanks with a high storage capacity and a high likelihood of release during natural hazards.
- The design basis of hazardous installations is not always adequate for natural-hazard loading and design limits need to be understood and acknowledged.
- Natech risk-reduction measures are available for several natural hazards and research is ongoing to fill existing data and knowledge gaps.

The third presentation introduced the fundamentals of industrial risk assessment. It gave an overview of the general risk-analysis process which aims to answer the three main questions of risk analysis: 1) What can go wrong?, 2) How likely is it?, and 3) What are the consequences? The different risk-assessment approaches commonly used (qualitative and quantitative) were also addressed, including a more detailed discussion of accident consequences in general, and the JRC's ADAM tool for consequence analysis in particular. Examples of risk-acceptability criteria and uncertainties inherent in the risk-assessment process (models, input data, level of detail of the analysis) were also given. This presentation's key messages are:

- Risk assessment is a structured process to identify hazards and assess the risk associated with them.
- The completeness of the risk analysis can never be ensured.
- Due to the many inherent uncertainties in the risk-assessment process, the final risk figure gives only an indication of the risk level. However, the overall process of risk analysis helps to identify system weaknesses and to prioritize the implementation of safety measures.

After the introduction of the fundamentals of industrial risk assessment, the next presentation discussed the specific case of Natech risk assessment which differs in some important aspects from conventional risk assessment (e.g. the necessity to consider multiple and simultaneous release scenarios common during Natech accidents). In fact, regardless of the risk-assessment approach chosen, extensions to both qualitative and quantitative risk assessment are necessary to fully consider Natech characteristics. The presentation outlined the individual steps in Natech risk assessment and gave detailed examples of the issues to be addressed for every step. It also emphasized potential pitfalls that attention should be paid to (e.g. the need to consider the reactivity of some chemicals with water in case of Natech accidents caused by floods, heavy rain or tsunamis, or the fact that implemented protection measures may have been rendered non-functional by the very natural hazard that caused the Natech accident). The key messages of this presentation are:

- The development of Natech risk assessment and mapping tools is a high-priority need to understand where Natech risk zones are.
- Natech risk assessment requires additional assessment steps and models as compared to conventional industrial risk assessment.
- The JRC has developed the RAPID-N framework for rapid Natech risk assessment and mapping which can be used to quickly identify Natech risk hotspots.

2.2 Introduction to RAPID-N and case-study scenarios

The second module of the training workshop was entirely dedicated to introducing the JRC's RAPID-N tool and providing hands-on training on its use. RAPID-N is a unique, web-based assessment and mapping framework that unites a *natural-hazards module* which calculates natural-hazard severities at the site of the hazardous installations, an *industrial plants and units module* which provides all data related to the installation and its units, and a *risk-assessment module* in which the equipment damage from the natural hazard is assessed using fragility curves, and the site risk assessment is performed. A property estimation framework, which helps the user carry out a Natech risk assessment with a minimum of data input, is an integral part of RAPID-N[4,5].

RAPID-N is currently implemented for assessing earthquake impacts at fixed chemical installations. It also includes a draft implementation of assessing the risk to oil and gas pipelines under seismic loading. RAPID-N is available at: http://rapidn.jrc.ec.europa.eu. The tool is public and use is for free. However, prior authorization by the JRC is required for using its risk assessment functionality.

The risk-assessment process with RAPID-N was demonstrated by guiding the workshop participants step by step through a case study that estimated the impact of the Istanbul earthquake scenario on a hazardous installation that suffered significant damage during the 1999 Kocaeli earthquake. Subsequently, participants worked on their own RAPID-N example country case study using 21 hazardous installations and credible earthquake scenarios.

For this purpose, earthquake scenarios were taken from the earthquake database of RAPID-N which provides world-wide earthquake data for $M > 5.5$ starting from 1970. Since also hazard maps (ShakeMaps) were available in RAPID-N, users did not have to collect earthquake hazard data but could use what was provided by RAPID-N. The JRC suggested an industrial plant for analysis for each country based on its importance (related to dimensions). In most cases a refinery was selected, but for some countries storage terminals were suggested instead. The participants were free to work on one of the installations suggested by the JRC or choose another plant for the hands-on study.

For the chosen installation, the participants delineated its boundary in RAPID-N and entered site (urban/rural area, soil conditions) and operator data based on public information available online. They then mapped the storage tanks in the facility by using the mapping tool built into RAPID-N. This allowed the mapping of units, which included dimensions (e.g. diameter) and characteristics (e.g. roof type) in a very short time period. Some participants entered tens of units during the exercise.

Subsequently, the Natech risk assessment with RAPID-N was demonstrated in two steps: 1) damage assessment where data on the chemical substance was missing, and 2) risk assessment if substance data was available. If substance information is missing, RAPID-N cannot calculate the consequences of hazardous-substance releases and instead stops after the calculation of the damage to units caused by the earthquake. In this case the tool calculates equipment damage probabilities by estimating onsite hazard parameters and choosing the most appropriate fragility curve for each unit based on the unit characteristics. The participants saw how missing data is automatically completed by RAPID-N and how the results are reported.

For the second step, participants provided substance information by selecting flammable or toxic substances from the RAPID-N database. The users did not have to collect data on the chosen chemicals because the database also includes physico-chemical properties of substances. With this information, the risk assessment was re-run and RAPID-N created possible accident scenarios and calculated the end-point distances of the associated consequences (toxic effects and burns). The participants learned how the results of the risk assessment are reported and mapped.

RAPID-N performed well during the exercise with a rapid completion of the case-study calculations in spite of the about 20 risk-assessment test cases that were run simultaneously. Furthermore, participants used different platforms for running RAPID-N, such as Windows and OS X laptops, as well as Android tablets. The user experience was the same in all cases.

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[4] S. Girgin, E. Krausmann (2013) RAPID-N: Rapid Natech risk assessment and mapping framework, Journal of Loss Prevention in the Process Industries, 26, 949.

[5] S. Girgin (2012) RAPID-N: Rapid Natech Risk Assessment Tool - User Manual, version 1.0. JRC Scientific and Policy Report EUR 25164 EN.

3 Country presentations

All countries invited to the workshop were asked to prepare a brief country presentation that would address the following five questions:

i. Which natural hazards are a major concern in your country and which regions are exposed to these hazards?

ii. Are there any major industries (e.g. refineries, hazardous facilities, and pipelines) located in natural-hazard regions? If yes, please list the main industries.

iii. Did any Natech accidents happen in your country in the past? If yes, please list the major ones.

iv. Do regulations, codes or practices for chemical-accident prevention or civil protection in your country address the risk of natural-hazard impacts on hazardous industry? If yes, for which natural hazards?

v. What would be the main needs in your country to ensure effective Natech risk reduction?

Two EU Member States, Malta and The Netherlands, also prepared a country presentation. The brief country profiles below are a summary of these presentations.

<u>Albania</u>

The Albanian territory is subject to geological (earthquakes, landslides and rock falls), meteorological (floods, heavy rain, snowstorms, windstorms) and bio-physical (forest fires) hazards. The largest landslides have developed in the basins of the main hydropower plants of Fierza, Vau I Dejes and Banja. The Buna and Drini River basin in the North West and the Semani River basin in the South West are at risk of floods and heavy rain, while the North East of Albania is subject to snow and storms. Oil wells (Bankers petroleum) and oil storage in Durres are located in flood zones. The Trans Adriatic Pipeline Project is in the first phase but will pass areas subject to flood and snow hazards.

Albanian Civil Protection collaborates with universities and different ministries to address the natural hazards Albania is subject to. New national strategies are harmonized with EU regulations and initiatives. For effective Natech risk reduction, there is a need to:

1. Increase awareness and government preparedness;
2. Increase attention to this problem by hazardous industry and other possible investors in Albania;
3. Test of the National Emergencies Plan in particular in the areas at risk.

<u>Algeria</u>

Several regions in Algeria are subject to very high earthquake and flood risk. Floods are often caused by torrential rains when the water absorption by the ground is hampered due to the impermeability of the soil in urban areas. Most high-risk industrial installations are located in the North of Algeria, which is also a highly seismic zone but to date no Natech accidents have been registered.

Out of the 48 departments in Algeria, 25 are considered to have high to very high industrial risk. Algeria has six major risk areas which have been declared by Executive Decree. One of these areas, the industrial zone of Skikda, is both flood- and tsunami prone. Similar to the EU, also in Algeria the competent authorities shall ensure that the operator of a hazardous installation is obliged to take all measures necessary to prevent major accidents and to limit their consequences for people and the environment. Legislation on the prevention of major risks and disaster management in the context of sustainable development (Law No. 04-20, December 25-2004) provides measures and tasks to be undertaken by national institutions before (prevention plan for each major risk) and after a disaster (emergency planning).

In terms of needs related to Natech risk reduction, the following items were identified for Algeria:

1. Integration of disaster risk reduction into policies and plans for sustainable development;
2. Development and strengthening of institutions, mechanisms and capacities to build resilience to hazards;
3. Risk-analysis tools;
4. Preparation of Natech risk maps.

Armenia

Although prone to many different natural hazards, 80% of the Armenian territory is subject to severe earthquake risk with four seismic fault lines crossing the country. Other important natural hazards are mudflows, flash floods and floods, as well as hail and drought. A very small percentage of Armenia is prone to landslides and rockfalls.

With respect to industrial risks, in Armenia there are 23 registered organisations that use chemical substances, e.g. chlorine, ammonia, nitric acid, etc. Over 1,500 enterprises are at a risk of fires and explosions. Furthermore, Armenia has 82 water reservoirs, 24 tailings reservoirs, as well as a nuclear power plant in Metsamor. Several government decisions regulate the response to man-made accidents: Decision N861-N of July 2010 addresses accidents at chemical facilities, while Decisions N 2328-N (December 2005) and N8 (March 2016) regulate nuclear and/or radiological accidents on Armenian soil.

Although to date no Natech accident has been recorded in Armenia, several areas of improvement to reduce this risk were suggested:

1. Development of monitoring, prediction and early-warning systems;
2. Increase of awareness of government bodies and the population, as well as targeted training;
3. Improvement of regulations related to disaster risk reduction;
4. Strengthening and expansion of international cooperation in the field of disaster risk reduction;
5. Development and introduction of insurance against losses from disasters.

Azerbaijan

Earthquakes are an important hazard in Azerbaijan with magnitude 8.9 refraction zones. Mapping of these seismic risk zones together with industrial areas gives an indication of Natech hazard hotspots due to earthquakes. Landslides caused by heavy precipitation occurred in 2003 including in the Great Caucasus region where oil and gas fields are located. Flooding is also an important risk which is triggered by snowmelt, heavy rain or flooding of the river Kura. An additional hazard considered natural is the fluctuating level of the Caspian Sea which has slowly risen by 2.5 m since 1978. Currently, the sea level is again in decline.

Azerbaijan’s main oil industry is located in and around Baku. Several hazardous installations are situated in areas subject to natural hazards, e.g. the Heydar Aliyev Baku oil refinery, the Azneft gas processing plant, and the Sangachal oil and gas terminal. In addition, several oil and gas pipelines cross Azerbaijan and pass into other countries, e.g. the Baku-Tbilisi-Ceyhan (BTC) oil pipeline, the Baku-Novorossiysk or Northern Route Export oil pipeline (NREP), the Baku-Supsa or Western Route Export oil pipeline, and the South Caucasus gas pipeline (SCP).

The Baku earthquake in 2000 affected production from oil fields via an increase of the oil debit from wells and added to the risk of oil spills. Seismic risks are expected for former oil wells, and the Ministry of Ecology and Natural Resources requests geophysical data for preparedness purposes once oil and gas wells are decommissioned. Floods are a recurring threat in Azerbaijan and have on multiple occasions resulted in major infrastructure damage although no Natech accident was reported. The Gunashli oil explosion is considered to have been caused or influenced by weather (storm conditions).

The activities of the State Oil Company of the Azerbaijan Republic (SOCAR) and of BP Azerbaijan are governed by an Action Plan to ensure the preventative and timely operational implementation of measures against accidents during production, refining and the transportation of hydrocarbons both on- and offshore. The main emergency measures during accidents are the Oil Spill Alert and Response Plan of SOCAR and BP's Emergency Action Plan on oil spills at onshore and offshore installations. The risk of accidents at hazardous installations is owned by two Ministries. The Ministry of Ecology and Natural Resources (MENR) is the coordinating entity which regulates relevant structures at the time of an accident, and the Ministry of Emergency Situations (MES) which is the national authority in charge of the elimination of accidents (preparedness and response).

The main identified needs related to Natech risk reduction for Azerbaijan are:

1. Institutional and legal developments (e.g., issuing as MENR or MES when it comes to the commissioning of main industries due to their preparedness level);
2. Capacity building on disaster risk management, with a particular focus on prevention and preparedness;
3. Improvement of forecasting or monitoring technologies;
4. Application of best practices for chemical-accident mitigation taking into account economic factors.

<u>Croatia</u>

The Croatian territory is prone to earthquakes, floods, landslides and hurricane-force winds in coastal areas (the so-called Bura which can reach wind speeds of about 150 km/h and can last for several days). More frequent and stronger weather extremes have been recorded in Croatia. The country is home to 31 upper-tier and 34 lower-tier chemical facilities according to the definition of the EU Seveso Directive. Two important hazardous installations are located in zones subject to high natural-hazard risk: the Sisak refinery near the river Sava and the crude-oil terminal on Krk Island.

Croatia suffered a major dam break caused by unprecedented flooding in Gunja in the East of the country in 2014. The water level reached a 1,000-year average height of 1,193 cm. The most severe threat manifested along a length of 67 km on the embankment of the Sava River with 12 very critical points. The highest rainfall occurred on 14-17 May 2014 with 91 l/m^2. Once the floodwaters receded, around 117,000 m^3 of waste remained.

The Framework Agreement on the Sava River Basin, whose establishment is in progress, will adopt a protocol on acute situations with the purpose to prevent, prepare for, and respond to emergencies, and ensure mutual cooperation between the parties to the protocol. Chemical accident prevention is addressed through the Regulation on Major Accident Prevention (O.G. 44/14) which transposes the Seveso Directive into national law, and the Environmental Protection Act (O.G. 80/13, 153/13 and 78/15). Civil protection, which is the remit of the National Protection and Rescue Directorate, is regulated by the Civil Protection Act (O.G. 82/15) and the Regulation on Methodology for Threat Assessment and for Rescue and Protection Plans (O.G. 30/14 and 76/14). The latter includes plans for hazardous industry and units of local self-government.

In order to ensure effective Natech risk reduction, Croatia indicated a need for:

1. Capacity building in risk assessment including Natech accidents, e.g. via dedicated workshops, study visits, or projects with interdisciplinary participants;
2. Dedicated guidelines, manuals and case studies;
3. Financial support for purchasing equipment for emergency response.

Egypt

The most important natural hazard in Egypt is torrential rain that causes flooding. The regions that are exposed to this type of hazard are the Nile Valley from Cairo to Aswan, the Eastern desert (Red Sea region), the Sinai Peninsula (north and south) and the Matrouh region.

In 1994 heavy rains caused a Natech accident in the village of Dronka, where flammable hydrocarbons released from an aviation fuel depot were ignited by a lightning strike. The burning kerosene was dispersed throughout the village by the floodwaters, causing major human losses and economic damage.

The risks associated with torrential rain are mitigated by the competent authority through identifying and inventorying villages and communities exposed to this type of risk, raising awareness and preparedness levels in emergency centres, cleaning and developing natural or artificial storm water drains, as well as the building of dams and culverts, and the preparation of economic feasibility studies for infrastructure to better protect buildings.

The biggest need for Natech risk reduction in Egypt is capacity building in Natech risk management.

Georgia

The main natural hazards Georgia is exposed to are floods, landslides and earthquakes. The main hazardous activities are related to oil and gas transport (e.g. the Baku-Supsa pipeline which transports oil from Azerbaijan to Supsa at the Black Sea; the Baku-Tbilisi-Cehan oil pipeline and the Baku-Tbilisi-Erzurum gas pipeline that originate in Azerbaijan, cross Georgia and end in Turkey), as well as oil terminals and waste storage from decommissioned industrial activities.

Over 100,000 tons of arsenic waste are stored in steel drums in the villages of Tsana and Uravi, both of which are located in the flood-prone basin of the Tskhenistskhali and Rioni rivers. This risk is not regulated and gives rise to concern, as these rivers are the freshwater source for half of Georgia. Any release of arsenic waste into the rivers would constitute a serious problem. The optimal solution would be to store the waste in a sarcophagus but this is very costly.

In fact, following an extreme hydro-meteorological event in 2013 which caused flooding of the Tskhenistskhali River and a change of the riverbed, the dam at the metallurgical plant in Lentekhi was damaged which subsequently resulted in the releases of arsenic waste from the steel barrels onsite.

Currently, hazardous companies are requested to identify all kinds of hazards related to their activities and to carry out an environmental impact assessment. In the frame of the EU-Georgia agreement it is planned that Georgia will implement the Seveso Directive into national law. The Seveso draft is ready and signature is expected by spring 2017.

Israel

The main natural hazards in Israel that could threaten hazardous-materials storage are earthquakes, floods and forest fires. In particular earthquakes and floods have a significant occurrence probability. All of Israel's territory is earthquake-prone, with high-risk areas in the Yagur Rift, Beit Shean valley, Eilat, the Arava desert and the Dead Sea valley along the Great Rift Valley. Floods occur along the coast, the Jordan valley, and the Jehuda and Negev deserts. Every state forest is at risk of wildfires.

Hazardous industry potentially threatened by these natural hazards are the fertilizer and petrochemical installations in Haifa Bay, Dead Sea factories (potash, magnesium chloride, various types of salts), the Mishor Rotem industrial park (e.g. phosphate mining and processing), the Ramat Hovav industrial park (e.g. bromine compound industry, hazardous waste disposal plant), and Ashdod and Haifa ports. The main concern surrounds Israel's ammonia plants, including the facility in Haifa, which is due to be relocated to Mishor Rotem.

There are no reports of Natech accidents in Israel to date. The Ministry of Environment issued a few documents that define how to protect ammonia facilities from earthquakes and how to conduct an environmental impact assessment that includes seismic risk. However, there are no general laws for Natech risk reduction, and response is limited and specific to each hazardous facility. Several actions are proposed for effective Natech risk reduction in Israel:

1. Mapping of the potential risks, their likelihood, and of risk-prone facilities.
2. Development of a framework for risk reduction that integrates different types of risk, both from a technical and organizational point of view, e.g. strengthen infrastructures and decrease their proneness to certain accident scenarios, protect sensitive areas, and prepare emergency-response procedures in collaboration with the facility management in risk-prone areas.
3. Development of specific regulations for Natech scenarios including support and professional guidance in the preparation process, enforcement and monitoring of the implementation, as well as updating of safety requirements for hazardous sites according to the most likely scenarios.

Lebanon

With Lebanon being a small country, most of its regions are prone to natural hazards. Multiple fault lines pass through the country, making it vulnerable to earthquakes. Of particular concern is the Mount Lebanon thrust off the coast which was only recently discovered. Lebanon is also prone to tsunamis. All refineries and oil and gas depots are located on the shore, exposing them to earthquake and tsunami hazards. The majority of chemical installations in the country belongs to the petrochemical sector.

No Natech accident has been reported in Lebanon. The country closely collaborates with the EU on a national action plan for CBRN incidents which includes accidents triggered by natural hazards. The main needs with respect to effective Natech risk reduction are related to prevention, preparedness and response. All these steps are included in the national response plan for CBRN which should be implemented soon.

Moldova

The Republic of Moldova is subject to floods and landslides and some hazardous industry in the South of Moldova is located in natural-hazard prone areas. This is, for instance, the Apa-Canal liquid chlorine storage in Cahul, Valexchim Ltd. oil storage in Valeni, and Danube Logistics Ltd. and the Trans Cargo Terminal in Giurgiuliesti where gasoline and diesel fuel are stored in large quantities. All industrial objects located in natural-hazard areas (floods) were identified in the frame of a TEIA project which included Ukraine, Moldova and Romania.

Moldova has to date not experienced Natech accidents. It was, however, indicated that improvements on the register of installations falling under TEIA might be necessary, considering that the related information is divided between three ministries. This fragmentation of information might have resulted in Natech accident data not being easily available.

Flood-risk management regulations include measures that aim to prevent flooding and minimize the consequences on the population and the environment. This indirectly addresses Natech risks.

The main needs with respect to effective Natech risk reduction in Moldova are:

1. Identification of all Natech risks that exist in Moldova;
2. Development of maps with all hazardous industry, chemical or other, located in all natural–hazard regions;
3. Capacity building to transfer the knowledge related to Natech risks;
4. Development of guidance on which measures to take in case of Natech accidents;
5. Development of software tools for risk modeling, and for air and water pollution;
6. Exchange of experience between industrializing countries in this domain.

<u>Palestine</u>

Palestine is vulnerable to the impact of natural hazards, mainly earthquakes, floods, landslides, droughts and desertification. However, it has also suffered major damage to agriculture and infrastructure by a severe winter storm in 2013. The chemical industry is spread throughout the West Bank and includes the manufacturing of different types of (petro)chemicals, basic metals, paper, leather, textiles, as well as machinery and equipment. These industries are regulated by a number of laws and bylaws that address environmental impacts, waste management, public health, worker protection, and disaster risk management.

No Natech accidents have been reported to date. The main needs that were identified are:

1. Preparation of a national program and a public policy related to prevention, preparedness and emergency response.
2. Specific training for staff in disaster risk management and rescue operations.
3. Legal framework for disaster risk reduction, as existing frameworks are very limited.
4. Inventory of hazardous industries and the chemical substances they handle.
5. Equipment and tools for handling chemicals.

<u>Serbia</u>

The major natural hazards in Serbia are floods, forest fires, landslides and earthquakes. Lately, the risk of flash floods has become increasingly important. Several Seveso upper-tier establishments are located in natural-hazard regions, e.g. a fertilizer plant, thermal power plants, fuel and LPG storage tank farms, a refinery and a petrochemical complex. Most Seveso plants are located on river banks. There are also a few non-Seveso mining sites in these regions, all of which are prone to floods. In contrast, none of these sites is located in areas that exhibit landslide, forest fire, or earthquake risks.

Serbia has not experienced a Natech accident. However, during the severe floods in 2014, a number near-miss events occurred when parts of several Seveso upper-tier complexes, all of which situated on river banks, were flooded. These installations had already been identified as Seveso-type prior to the flooding and had benefitted from the implementation of preventive measures, and internal emergency plans had been prepared. Thanks to adequate prevention and fast emergency response, these incidents did not escalate into Natech accidents. According to the Law on Emergencies and the Law on Environmental Protection (for Seveso sites) it is compulsory to consider natural hazards as external accident triggers at Seveso installations and all other industrial complexes in Serbia.

A number of requirements were identified to strengthen Natech risk reduction. These are:

1. Better land-use planning;

2. More education and detailed planning for prevention, preparedness and response;
3. Improved cooperation with neighboring and other countries;
4. More funding to ensure that all defensive measures will be available.

Ukraine

The main natural hazards in Ukraine are floods, landslides and earthquakes. In natural-hazard prone areas there are the main oil, gas and ammonia pipelines of the country, and 967 chemical installations, 97 of which handle 1st degree chemical hazards. There is a concentration of high-capacity hazardous activities in the Eastern and Central parts of the country. In Ukraine a total of about 300,000 tons of hazardous chemicals are handled (including 3,800 tons of chlorine and 194,000 tons of ammonia).

The Natech events that occurred in Ukraine originate with an increase in water flows, karst collapse and landslides which have led to the uncontrolled flooding of mines in Kalush (Ivano-Frankivsk district in the Carpathians) and Solotvyno (Zakarpattia district). As a consequence, in Kalush there is a risk of cross-border pollution runoff into the Limnytsya and Mlynivka rivers, which are tributaries of the transboundary Dniester River, and therefore a threat to both Ukraine and Moldova. At Solotvyno salt mine a large amount of salt water was spilled into the transboundary Tisa River which may cause large-scale negative environmental impacts within the territories of Ukraine and Romania. Both emergency situations persist to date.

Ukraine has no specific regulations for Natech risk reduction but the threat is implicitly included in the general chemical-accident prevention framework. The Code of civil protection regulates the prevention of emergencies and consequence management, including at (petro)chemical and pharmaceutical facilities, and oil and gas pipelines. The Law on “facilities of increased hazards” regulates the identification of such facilities, siting, safety reports and consequence management. Two ministerial orders (27.03.2001 No. 73/82/64/122 and 17.05.2004 No 87/211) define the methodology for forecasting the impact of accidents at industrial installations and transport, as well as associated prevention measures for chemical accidents, and describe coordinated response actions for nuclear and radiological hazards.

The main needs of Ukraine for the effective management of chemical accident risks (and therefore also Natech risks) are:

1. Expert assistance in resolving the environmental problems associated with the emergency at the Solotvyno salt mine;
2. Development of methodologies for risk assessment and of risk maps for certain types of emergencies (Ukraine has developed a concept for the management of man-made and natural risks, however, the methodologies for implementing the concept are not available);
3. Provision of modern detection instruments for pollution for emergency rescue units and the chemical and radiometric laboratories of the State Emergency Service.

Malta

Malta is considered to be at medium earthquake risk; other natural hazards potentially relevant are tsunamis and thunderstorms. Due to the size of the country, a natural hazard could affect the entire island. The major storage facilities and industrial installations are manly situated in the southern part of Malta. Fuel storage facilities are located underground and above ground while fuel pipelines span halfway across the country.

While no Natech accident has happened in Malta, earthquakes could rupture fuel pipelines which could under certain conditions cause flammable spills (the pipelines are normally kept empty). Similarly, if an earthquake damaged underground fuel tanks with subsequent releases in the underground complex it would create groundwater problems and lead to spills of petrochemical products inside the harbors. Tsunamis would affect fuel storage facilities as they are all located in the harbor basin. Since Malta has only one power station, a tsunami would likely down the whole electrical power generation, except possibly the interconnector from Sicily. Thunderstorms could trigger storage tank fires.

For recently built or planned hazardous installations natural hazards have to be taken into account. The Planning Authority consults with the Seveso competent authority regarding new sites, however there are no established codes for Natech risk reduction. HSE codes are applied as standard practice. Prevention measures for natural risks involve lightning protection and measures against flash floods. Newer sites would also include protection against earthquake loading from local seismic activity, as well as procedures for total shutdown in case of a strong natural event. Older installations are more vulnerable to natural hazards as they have not benefitted from the same levels of protection as recent or new sites.

The main needs identified for Natech risk reduction mainly relate to emergency response due to oil spills, as well as protection of the population from natural hazards:

1. Tsunami early warning system to facilitate the alerting and evacuation of the population, as well as to ensure departure of ships from the harbor to keep them from being washed onshore;
2. Emergency-response equipment to combat pollution from major oil spills for which national resources might be insufficient.

It was emphasized that in case of a natural-hazard impact, the whole country would be affected from a logistics point of view, and electricity generation would potentially be an issue. Also, in case of accidents at fuel storage facilities a shortage in fuel supply could result.

The Netherlands

The Netherlands are subject to earthquakes, thunderstorms, heavy rain and high tides that constitute a hazard. In the southeast, earthquakes are caused by an active rift zone while seismic activity in the northeast is induced due to the exploitation of the Groningen gas field. Seveso facilities and gas pipelines are located in natural-hazard prone areas.

The country has experienced a Natech accident when a lightning strike caused a fire at the TEAM terminal in the port of Rotterdam in 1998. The rim seals of two large 80 m tanks ignited due to lightning impact leading to a major fire.

In terms of regulatory frameworks, Dutch Seveso facilities have to identify the natural hazards they are exposed to and consider them in the site safety assessment. In addition, there are a number of regulations and acts that support prevention, preparedness and response related to accidents involving high-risk industries. For instance, the Dutch External Security Registration Decision requires risk situations with hazardous substances to be registered. The Environmental Management Act stipulates the conditions that a company must meet to obtain a permit for using or storing hazardous substances. From a regional point of view, ministerial regulations describe the vulnerable objects and high-risk situations that must be shown on a risk map. The Security Regions Act collects first responders (fire department, medical assistance, etc.) in a single organization in case of accidents and disasters.

It was mentioned that exploration work in the gas fields should be reduced to decrease the earthquake risk in The Netherlands. Remodeling and the retrofitting of (new) homes and structures to decrease their vulnerability to natural hazards, as well as disaster reduction are also needed.

4 Discussion and outlook

The workshop showed that the participating countries are experiencing the same difficulties related to Natech risk reduction as EU and OECD countries:

1. The Natech risk in some countries may be very high, as many countries are subject to natural hazards and hazardous industries are located in natural-hazard prone areas.
2. Some countries have already experienced Natech accidents in their territory. In addition, the threat of a cross-boundary Natech accident is a high concern for some countries.
3. Frameworks for chemical-accident prevention and preparedness exist, but Natech risks are rarely considered.
4. In many cases, competences associated to chemical accident and Natech risk reduction are distributed across different ministries and require good coordination between ministries to achieve maximum effectiveness.
5. Countries expressed a strong need for Natech risk-assessment methodologies and tools, guidance on Natech risk reduction, Natech risk mapping, early warning systems, and awareness raising and training.
6. Several countries are interested in mitigation and response strategies when there are also impacts on infrastructure from natural disasters that could hinder the response to the Natech event or exacerbate its effects.
7. Several countries indicated a need to apply land-use planning and defensive measures to reduce vulnerability to Natech accidents.
8. A number of countries mentioned a need to purchase equipment to help with response to a Natech event.

Most participants had been aware to some extent of the existence of Natech risks prior to the workshop although there was a general belief that this was not necessarily the case among practitioners in the invited countries. There was also some recognition that climate change might affect the Natech risk situation in many countries, and attention might have to be paid to some natural hazards that are currently not considered as relevant. This makes targeted Natech prevention and preparedness even more important. The participants also acknowledged that the needs of their countries with respect to Natech risk reduction were very similar and that it was helpful for them to network and exchange information and experiences with other countries.

The feedback of the workshop participants on the two days of the training was very positive, with a strong interest shown in risk assessment in general, Natech risk assessment in particular, and in learning about RAPID-N and its capabilities. This indicates a strong interest in risk assessment as a process to increase industrial safety, and in the available associated support tools. However, almost all participants agreed that while the workshop transferred valuable knowledge on Natech risk-assessment approaches, the time was too short for providing sufficient hands-on training in the use of RAPID-N. It was suggested to organize 3-day training in the future, with more time for practical study in small groups. It was also indicated by some participants that this future training could be coupled with a RAPID-N user certification process.

Subsequent to this training workshop, a number of meetings with countries who have expressed interest in bilateral contacts have already take place. Several participating countries requested that the training be offered also in the future to both EU and non-EU countries. The JRC has scheduled another training slot for February 2017 for EU Member States. This training will be organized in the frame of the EU Disaster Risk Management Knowledge Centre's Support Service. Further training opportunities exist and can be customized to a specific country's needs. This training can then be held in a specific country or, if preferred, at the premises of the European Commission's Joint Research Centre.

The Joint Research Centre will continue the development of RAPID-N and will release a prototype for flood Natech risk assessment in autumn 2017. This echoes the request of some participants who are concerned about flood Natech risk in their countries. We are currently exploring the feasibility of linking RAPID-N with the European Flood Alert System (EFAS) which could provide near-real time flood information as input for the Natech risk assessment. Another future development will concern the inclusion of domino effects in RAPID-N, a phenomenon that is more frequent during Natech accidents.

Considering that the quality of RAPID-N outputs is critically dependent on the reliability of the input data used for the risk assessment, some participants asked that the tool be shared with national authorities with a request to provide information on the country's hazardous installations in RAPID-N which would then be available for Natech risk assessment. In this context it was highlighted that RAPID-N provides full data confidentiality to users if they do not want to share their installation data in the RAPID-N database or the results of their risk assessment with other users. In order to increase the usefulness of the tool, countries could work with the Joint Research Centre to translate it into different languages. Due to the setup of RAPID-N this is relatively straightforward and would require only little time and effort.

Annexes

Annex 1. List of participants

Name	Affiliation
Abou Moussa, Georges	Directorate General of the Civil Defence, Lebanon
Belakroum, Nadir	Direction Générale de la Protection Civile, Algeria
Buljan, Hrvoje	Ministry of Environmental and Nature Protection, Croatia
Datishvili, Besarion	Ministry of Environment and Natural Resources Protection, Georgia
Fabbri, Luciano	European Commission, Joint Research Centre
Gidachyan, Tigran	Ministry of Emergency Situations, Armenia
Girgin, Serkan	European Commission, Joint Research Centre
Gyenes Zsuzsanna	European Commission, Joint Research Centre
Hendrych, Adam	Ministry of Interior, General Directorate of Fire Rescue Service, Czech Republic
Ihmied, Talib	Environment Quality Authority, Palestine
Karimli, Kanan	Ministry of Ecology and Natural Resources, Azerbaijan
Kovacs, Balazs	National Directorate General for Disaster Management, Hungary
Krausmann, Elisabeth	European Commission, Joint Research Centre
Luik, Toomas	Estonian Rescue Board, Estonia
Luli, Leonat	European Quality and Safety Control (EQSC), Albania
Meinster, Jan	Veiligheidsregio Rotterdam-Rijnmond, The Netherlands
Mohamed, Amany	Ministry of Environment, Egypt
Pisani, Anthony	Civil Protection Department, Malta
Polishchuk, Taras	State Emergency Service, Ukraine
Rosenbaum Cohen, Hadas	Israel Defence Forces, Israel
Schiliro, Roberto	European Commission, Directorate General ECHO
Srdi, Bojan	Ministry of Agriculture and Environmental Protection, Serbia
Stirbu, Svetlana	Ministry of Environment, Republic of Moldova
Vetere Arellano, Ana Lisa	European Commission, Joint Research Centre
Vorstman, Eric	Veiligheidsregio Groningen, The Netherlands
Wood, Maureen	European Commission, Joint Research Centre

Annex 2. Agenda

European Commission Joint Research Centre Workshop

Risk Assessment for Natural-Hazard Impact on Hazardous Chemical Installations

16-17 March 2016, Ispra, Italy

Room 3, Building 36

DAY 1 MORNING

Session 1: Workshop overview and Natech risk concepts		Moderator: Elisabeth Krausmann, JRC
09:00	Welcome	Georg Peter, JRC Roberto Schiliro, ECHO
09:15	Overview of the workshop	Elisabeth Krausmann, JRC
09:30	Introduction of participants	All
09:45	Overview of project on Seveso Capacity Building in EU Neighbour Countries	Maureen Wood, JRC
10:15	Introduction to Natech risk: Concepts, gaps and JRC activities	Elisabeth Krausmann, JRC
10:45	Coffee Break	
11:15	Introduction to Natech risk: Damage mechanisms, lessons learned and risk reduction	Elisabeth Krausmann, JRC
12:00	Discussion	All
12:30	Lunch	

DAY 1 AFTERNOON

Session 2: Introduction to risk assessment		Moderator: Elisabeth Krausmann, JRC
13:45	E & IA Country presentations	All
16:00	Coffee Break	
16:30	Fundamentals of risk assessment	Luciano Fabbri, JRC
17:15	Discussion	All
17:45	Adjourn	
18:00	Bus Transfer to Hotel	
19:30	*Dinner at Hotel Europa*	

DAY 2 MORNING

Session 3: Natech Risk Assessment Moderator: Serkan Girgin, JRC		
09:15	Recap of Day 1 and introduction to the programme of the day	Serkan Girgin, JRC
09:30	Approaches to Natech risk assessment	Elisabeth Krausmann, JRC
10:15	Discussion	All
10:30	Coffee Break	
11:00	RAPID-N: JRC's rapid Natech risk assessment and mapping framework	Serkan Girgin, JRC
11:45	RAPID-N example case study	Serkan Girgin, JRC
12:30	Lunch	

DAY 2 AFTERNOON

Session 4: RAPID-N Exercise Moderator: Elisabeth Krausmann, JRC		
14:00	Natech risk assessment and mapping hands-on case study using RAPID-N	Serkan Girgin, JRC
16:00	Coffee Break	
16:30	Interpretation of results	Serkan Girgin, JRC
17:00	Discussion and feedback on workshop	All
17:45	Adjourn	
18:00	Bus Transfer to Hotel or Airport	

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