CONSEQUENCES AND RISK MODELING OF NATECH IN INDUSTRIAL ENVIRONMENTS

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Keyword(s): *pollutant dispersion, Environmental compatibility, NaTech, air pollution*

Abstract

The objective of the work is to harmonize and integrate strategies to improve the quality management of the environmental matrixes in a complex industrial context, characterized by potential impacts on the environment and on human health due to NaTech hazards. In this work, the possible consequences of NaTech events on a complex industrial plant are considered. Particular attention is paid to the risk to the health of workers potentially present in the production plant. The consequences of a NaTech event on possible production processes involving hazardous substances are simulated, assessing the resulting environmental impacts, with particular regard to atmospheric emissions and the related risk to human health. By means of both established and innovative mathematical models, various modes of industrial accidents involving the release of hazardous substances on the ground and into the atmosphere are simulated. To this end, an existing industrial plant is considered as an example case study. A potential damaging event resulting from a NaTech event is applied to this scenario. In order to define the type of triggering event, a literature search has been conducted on the main existing NaTech databases. The results include the representation of the consequences of a NaTech event in terms of risk and environmental indices, with a view to contributing to the development of a possible integrated prevention methodology.

1. INTRODUCTION

Industrial sites, especially when characterized by a long-lasting operation in the past when adequate environmental legislation was still not in place, have been the source of impact on the environment due to emissions to air, water and soil. Actually, due to the enforcement of strict environmental legislation in the European community, the emissions of industrial activities are highly controlled (for example in the Environmental Integrated Authorization procedure concerning "big potential polluter" industries). Nevertheless, although emissions are within the limits imposed by the legislation, there is still a strong need to evaluate the environmental quality in a complex industrial context, characterized by potential impacts on the environmental and on human health due to, for example, NaTech (Natural and Technological) hazards, which refers to industrial triggered by natural events such as storms, earthquakes, flooding and lightning.
Such a kind of assessment is needed for:

- correct planning of future industries and activities on the potentially affected land. This is, for example, the case of the environmental impact evaluation foreseen by the Italian/European legislation for the evaluation of specific projects [Italian Republic, 2006; European Union, 2014];
- the definition of technical interventions useful to contain the environmental impact of actual industrial activities (for example, in the framework of the integrated environmental authorization) [Italian Republic, 2006; European Union, 2010];

- the analysis of the current environmental impact of operating industrial activities. This is, for example, the case of the environmental health impact assessment foreseen by the Italian/European law for specific industrial installations [Italian Republic, 2006; European Union, 2014].

A comprehensive impact assessment of industrial sites requires to consider the contribution of diffuse sources from the operating plants and from the eventually contaminated subsoil, besides the usual conveyed emissions from stacks, plus to correlate the concentration at the point of exposure with the potential health risks on the receptor.
The modeling approaches used to deal with all emissions potentially produced at an industrial site, i.e. diffuse or concentrated emissions from the operating plant and diffuse emissions from the contaminated sites, are fairly different [Swartjes, 2015]. Diffuse and conveyed emissions from industrial operating plants are usually evaluated using advanced dispersion models, which simulate the pollutant dynamics in the atmosphere (e.g. Gaussian or Lagrangian models like Calpuff, Spray, Aermod and others). On the one hand, these models allow to simulate the pollutant dispersion in case of multiple and complex emission sources, non-steady atmospheric conditions, and variable orography. On the other hand, these tools require detailed input datasets of the meteorology and geophysical features of the area under study. Also, running these models requires a high effort in terms of human resources and computational time, and their use is limited to specialists in the field [Holmes and Morawska, 2006; Khan and Assan, 2021]. Advanced dispersion models are currently applied to Health-Environmental Risk Assessment. Research activity has presently been taken to improve such integrated approach and the harmonization of these methodologies. The approach used to evaluate the impact of contaminated sites on the environment and potentially exposed human receptors is currently integrated into the Health-Environmental Risk Assessment. Health-Environmental Risk Assessment methodologies were internationally developed for contaminated sites (ASTM E1739, 1995; ASTM E2081, 2000) considering the evaluation of impacts due to specific chemical or physical agents in a particular site and time, with the aim of protecting human health at the local level. In Italy, the Health-Environmental Risk Assessment has been standardized for operators by ISPRA Public Agency with 2008 Guidelines and following modifications [ISPRA, 2008]. Presently, national and international software are available on the market (e.g., Risk-net, RBCA, RISC and others) performing level II risk analysis, which relies on the description of pollutants dynamics in air, water and soil through over-simplified analytical equations, which generally provide an approximate, and usually overestimated evaluation of the impact on the receptors.
In this work an existing industrial plant is considered as an example case study. A potential damaging event resulting from a NaTech event will be applied to this scenario. In order to define the type of triggering event, a literature search has been conducted on the main existing NaTech databases. The results will include the representation of the consequences of a NaTech event in terms of risk and environmental indices, with a view to contributing to the development of a possible integrated prevention methodology.

2. MATERIALS AND METHODS
2.1 Analysis of the Current situation and considerations

The starting point of the work was the review of the NaTech databases, collecting information on industrial accidents caused by natural events that caused the release of toxic gases into the atmosphere. The following databases were analyzed:

- Emars Database: incidents and situations without injuries in the European Union.
- eNATECH Database: a database on technological incidents caused by natural risks.

From the database the characteristics of a specific case was chosen in order to perform the current work. In particular we chosen a case where strong winds (up to 150 km/h) caused the uncontrolled movement of a crane, leading to its collapse and damaging an ethylbenezene storage tank. After a realistic scenario of an industrial settlement with complex configuration was taken into account (Figure 1) and solvent (ethylbenzene) atmospheric dispersion in normal operating conditions was simulated with a microscale lagrangian dispersion model (Figure 2, baseline scenario).

Figure 1. Plan view of the case study

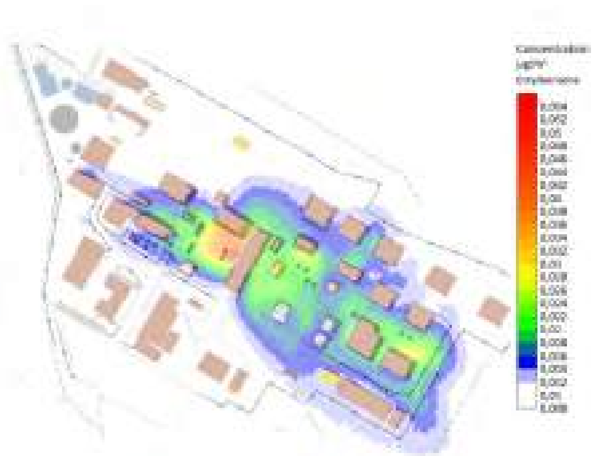


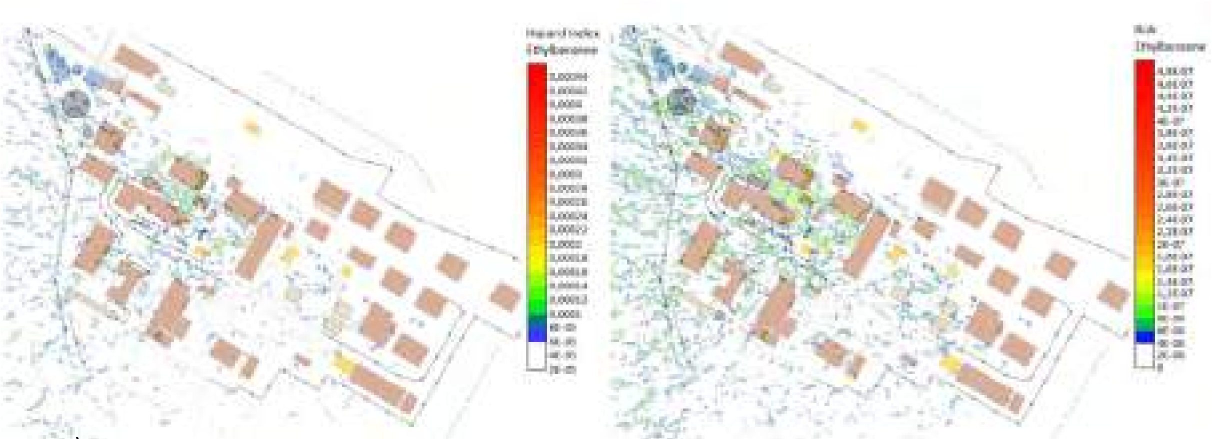
Figure 2. Average solvent concentration

The maps concerning the pollutant concentration was matched with the health environmental risk analysis (Figure 3). From the risk assessment point of view, it is important to note that:

- long- and short-term risk assessment was conducted on the baseline scenario
- carcinogenic risk (R) and hazard index (HI) were defined based on TLV-TWA exposure limits for occupational activities

- $R = \frac{C_{air}}{RC_{canc}} * 10^{-6}$
- $HI = \frac{C_{air}}{RC_{no,canc}}$

with
C_{air} = average pollutant concentrationin the air
RC_{canc} = reference concentration for carcinogenic effects
$RC_{no,canc}$ = reference concentration for non − carcinogenic (toxic)effects



a) b)

Figure 3. Hazard index (HI) (a) and Carcinogenic Risk (R) (b) for ethylbenzene inhalation, based on 98° pecentile modelled concentration

The current situation will be compared with the future situation (after the NaTech incident). In order to define the future situation, the procedure reported in the following flow chart (Figure 4) will be analyzed.

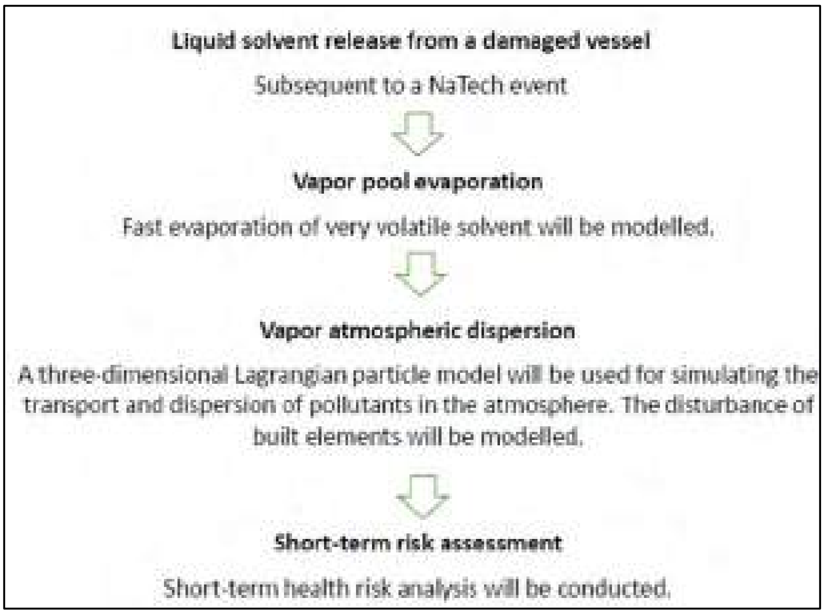


Figure 4. Procedure for future situation

With this comparison the main difference between the two situations can be highlighted and so it will be possible to analyze the main critical issues arising from this event.

3. CONCLUSION

The paper examines an existing industrial plant. For this baseline scenario the environmental impact (in terms of emission coming from the industrial plant) and the actually risk were defined. A potential damaging event resulting from a NaTech event will be applied to this scenario. In order to define the type of triggering event, a literature search has been conducted on the main existing NaTech databases. The final results will include the representation of the consequences of a NaTech event in terms of risk and environmental indices. In particular the results in terms of concentration (coming from the implementation of a specific pollutant dispersion model) are used in order to evaluate (with the use of a specific risk model) the risk for the human health of a Natech event. The main is to try to contributing to the development of a possible integrated prevention methodology.

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Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani

This study was carried out within the RETURN Extended Partnership and received funding from the European Union Next-GenerationEU (National Recovery and Resilience Plan – NRRP, Mission 4, Component 2, Investment 1.3 – D.D. 1243 2/8/2022, PE0000005) – SPOKE TS 2