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Considering critical infrastructures in the land use planning policy around Seveso plants

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ABSTRACT

The damages following major accidents in chemical facilities highlight civil society vulnerability to these risks. Many countries have drafted guidelines to prevent such accidents and to reduce the consequences for humans and environment. However, the consequences of such accidents on critical infrastructures (CI) and the cascading effect that may result are rarely considered.

In Europe, the Seveso Directives set out the major principles underlying prevention policy for these risks. Consequently, European Member States must assess the risks to which establishments (schools, hospitals, ...) are exposed. However, in evaluating risks, only scenarios involving accidents which directly harm humans are generally studied. Damages which could cause the failure of a CI, necessary for the proper functioning of the territory, are not directly considered.

This study briefly presents the risk quantification approach used in the Walloon Region (Belgium), which does not consider CIs interdependencies but can be adapted to do so. To illustrate the benefits of considering CI, the results of a simulated explosion in Montreal (Canada) are presented and show that taking CIs into account is more than relevant.

A possible line of approach is proposed to allow the risks related to CI failures to be addressed in the Walloon method.

1. Introduction

Over the last half-century, several major accidents have occurred in chemical plants in different member states of the European Union. The social, economic and environmental damages, as well as loss of human life, were considerable.

That is why in 1982 the member states enacted *Directive 82/501/EC*, better known as the *Seveso Directive I* (Council of the European Union, 1982). As a result, all member states must follow a common approach to the prevention of major accidents. Based on the quantity of dangerous substances present in excess of a first or second threshold value (minimal quantities), many facilities have since become *Seveso lower-tier* or *higher-tier* establishments. The Directive was revised in 1996 and renamed the *Seveso II Directive* (Council of the European Union, 1996), then amended in 2003 (Council of the European Union, 2003). The latest update was done in 2012 and bears the name *Seveso III Directive* (European Parliament and Council of the European Union, 2012). This version is applicable since June 2015.

The overarching purpose of the *Seveso Directive* is to apply all the necessary measures to prevent major accidents and, in the event an accident does occur, to limit its consequences for human beings and the environment. One of the main tools to meet the latter objective is land-use planning around Seveso sites.

The Seveso II Directive adopted in 1996 by the European Union states that domino effects should be included in risk analyses for chemical plants. Large literature is available about modeling and prevention of domino effects in industrial facilities (Reniers and Cozzani, 2013; Necci et al., 2015; Darbra et al., 2010). However, in Belgium little concern is addressed about domino effects related to infrastructures in the surroundings of a Seveso site.

In Belgium, land-use planning is a regional responsibility. Consequently, the Public Service of Wallonia is responsible for issuing an opinion on any land-use project in the vicinity of Walloon Seveso sites. In Wallonia, the process governing land-use planning around high-risk facilities involves two steps: first, the risk around the facilities in question must be quantified; second, this risk must be managed. In other words, it is necessary to determine what kind of land use is acceptable.

This process evaluates the risks of having establishments (homes, schools, hospitals, etc.) close to a Seveso site based on

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the number of people likely to be there and their vulnerability. In evaluating these risks, only accident scenarios that give rise directly to harm to human beings are taken into account. Damages that could cause the failure of a critical infrastructure (CI) that is located nearby and is necessary for the proper functioning of the territory are not considered. The consequences of the failure of the CI for other CIs are not taken into account either. Nevertheless, all these kinds of damages could compromise the territory's functioning. Due to the interdependencies among CIs, the increased dependency of civil societies on the resources and services these infrastructures provide, and the increasing urbanization of cities, these consequences could be increased and affect more than just the zone hit by the anticipated direct damages (Zimmerman, 1996). Consequently, more people, businesses and CIs would be affected.

In this context, risk assessment must also take account of these vulnerabilities, which have not been studied much in the case of major accident risks (Erwann, 2003).

In this article, the risk quantification method used in the Walloon Region will be described briefly and we will show that, to take CIs into account, this approach would need to be adapted. For that, a concrete example of a case, developed by the Polytechnic School of Montréal, is presented to show that indirect damages due to the failure of a CI can be huge. Thanks to a joint Wallonia/Quebec project, a possible line of approach that will make it possible to consider risks due to CI failures have been proposed.

2. Land-use management in the Walloon Region

The management of land-use planning in the Walloon Region can be summarized in two major steps. The first step consists in quantifying the risk around Seveso facilities so that, in a second step, the land in the vicinity of these high-risk sites can be better managed. The risk quantification method chosen by the Walloon Region is a technique similar to the Quantitative Risk Assessment (QRA) method. To respond to the need to define the concept of appropriate distance between Seveso facilities and areas frequented by the public, the Walloon Region decided to introduce the concept of vulnerable zone around these Seveso sites. The vulnerable zone can be defined as an area in which the effects of accidents that are harmful to people or property can be observed, with a non-negligible probability of occurrence. The concepts of consequences (harmful accidents) and probabilities are clearly in evidence here.

In this subsection, the risk quantification method developed by the Polytechnic Faculty of Mons will be presented first, then we will describe how the Walloon Region manages planning on the basis of the iso-risk curves this method generates.

2.1. Description of the risk quantification methodology applied in the Walloon Region

The probabilistic approach used in the Walloon Region follows the workflow presented in Fig. 1.

This methodology is based on the concept of individual risk, which can be defined as "the annual frequency of experiencing a given damage due to an accident in the facility for a person located at a point considered to be permanent and unprotected."

To apply this method, Phast Risk QRA software, marketed by DNV (Det Norske Veritas) Software, is used to calculate individual risk. The application of this methodology and the values of the many parameters used in the software have been described in several articles (Delvosalle et al., 2006a,b).

Note that, contrary to a classic QRA approach, the risk quantification method developed in the Walloon Region is based on the effect thresholds corresponding to the appearance of the first irreversible damages to health, and not to lethality. The effect thresholds used for the three types of effects considered (overpressure, toxic and thermal) are set out in the Walloon Region's handbook (Service Public de Wallonie, Direction Générale des Ressources Naturelles et de l'Environnement, Cellule Risques d'Accidents Majeurs, 2005) and presented in Table 1. A recent review of approaches and Regulations related to thresholds for domino effects and safety distances is given in the paper of Alileche et al. (2015).

The different steps of the methodology lead to the determination of risk for each scenario studied for all the dangerous facilities on the site. These different contributions are then added together to obtain the overall risk posed by the Seveso site.

The results are presented in the form of iso-risk curves (annual frequency), which connect points with identical risk.

Based on these curves, the Walloon Region decides whether or not to grant a permit to build in proximity to a Seveso site, as a function of the type of project and the risk level.

2.2. Management of vulnerable zones

To better manage land-use planning in the vulnerable zones defined by iso-risk curves, the Public Service of Wallonia developed a matrix-type tool to support decisions regarding whether or not a construction project should be authorized near a Seveso site (see Fig. 2). The individual risk accepted for a given environment depends on the specific vulnerability of this environment to industrial risk. In general, the more occupants there are and the less autonomous they are, the lower the individual risk that will be tolerated. This matrix is reported in Fig. 2.

A project located in proximity to a Seveso site will be accepted if:

- A Type A project is not included inside the 10^{-3}/year iso-risk curve;
- A Type B project is not included inside the 10^{-4}/year iso-risk curve;
- A Type C project is not included inside the 10^{-5}/year iso-risk curve;
- A Type D project is not included inside the 10^{-6}/year iso-risk curve.

3. Taking critical infrastructures into account in the Walloon Region's methodology

As Fig. 2 shows, the land-use planning policy around Seveso facilities provides that any Type A infrastructure that does not require the presence of people (water tower, electric pylon, transformer, telephone antenna, etc.) can be constructed quite close to the boundary of the industrial site. That implies that CIs, which generally correspond to Type A structures, can be built close to Seveso facilities without any restrictions. This is because the risk assessment process considers only direct harm to the public.

Nevertheless, an exercise carried out in Montreal to simulate the explosion of a ship carrying chemicals in a port infrastructure clearly shows the importance of considering risks related to the failure of a CI. This exercise proved that the failure of a CI resulting from such an accident can affect the public indirectly because of the interdependency among CIs. By not taking this kind of "indirect" risk into consideration, the Walloon Region is underestimating the actual risk posed by Seveso facilities in its land-use planning.

The next section briefly outlines the problems affecting CIs and the effects of the simulated explosion on CIs on the territory of the city of Montreal.