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Proximity as an integral factor in the evaluation of the territorial risk under the European Seveso Directive: Application in Andalusia (South Spain)

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ABSTRACT

In this work, a geostatistical analysis of multivariate character is performed, which is based on the distance between establishments affected by the European Seveso Directive and the type of vulnerable receptors categorized as human, environmental or material. This study reinforces the importance of including the value of proximity, besides others already known and used, such as dangerousness, vulnerability and probability/frequency, in the evaluation of the chemical and environmental risk or simply in the evaluation of territorial compatibility. Data used in the study were a sample taken in the region of Andalusia (Southern Spain) during the year 2013. Likewise, based on the descriptive tables of frequencies, in terms of average proximities, a double ranking of territorial compatibility is provided for the land use and planning (LUP), which affects to establishments, dangerous substances and vulnerable receptors. The multivariate analysis based on the projection on a factorial plane of the correspondences reveals hidden relationships of proximity between vulnerable receptors and their relationship with the territorial strata, in a simple and intuitive way. Results obtained here suggest that the methodology can be extrapolated to any other study area, taking into account their particular environmental conditions.

1. Introduction

Major accidents in industrial establishments have negative consequences at internal and external level. History has served to warn society about these events, in order to try to prevent and minimize their occurrence. Recent catastrophic accidents, such as those in Enschede (Netherlands, 2000) and Toulouse (France, 2001) are still a matter of debate and analysis due to their severe consequences. There is a common element in these accidents that bind them to the society, which is the fact that a safety distance between the industrial establishment and nearby areas devoted to other activities for public use must be respected (Tugnoli et al., 2013).

The Art 12 of the previous Seveso II Directive "SIID" (Directive 96/82/EC, 1996) included requirements for Land Use Planning (LUP: "Land Use Planning") (Cozzani et al., 2006; Taveau, 2010). Likewise, the new "Seveso III" (Directive 2012/18/EU, 2012) that will take effect in July 2015, contains in its article 13 the same prerequisite with respect to this discipline and even extends the premises at multiple levels in case that any vulnerable receptors "VR" might result affected, which are now denoted as Threatened Objects "TO" (APELL, 1998).

Andalusia is the most populated autonomous community in Spain, with the second largest surface and it has been ranked as the second one most affected by the number of Seveso establishments. Schmidt-Thomé (2005) defined a ratio that measures the density of

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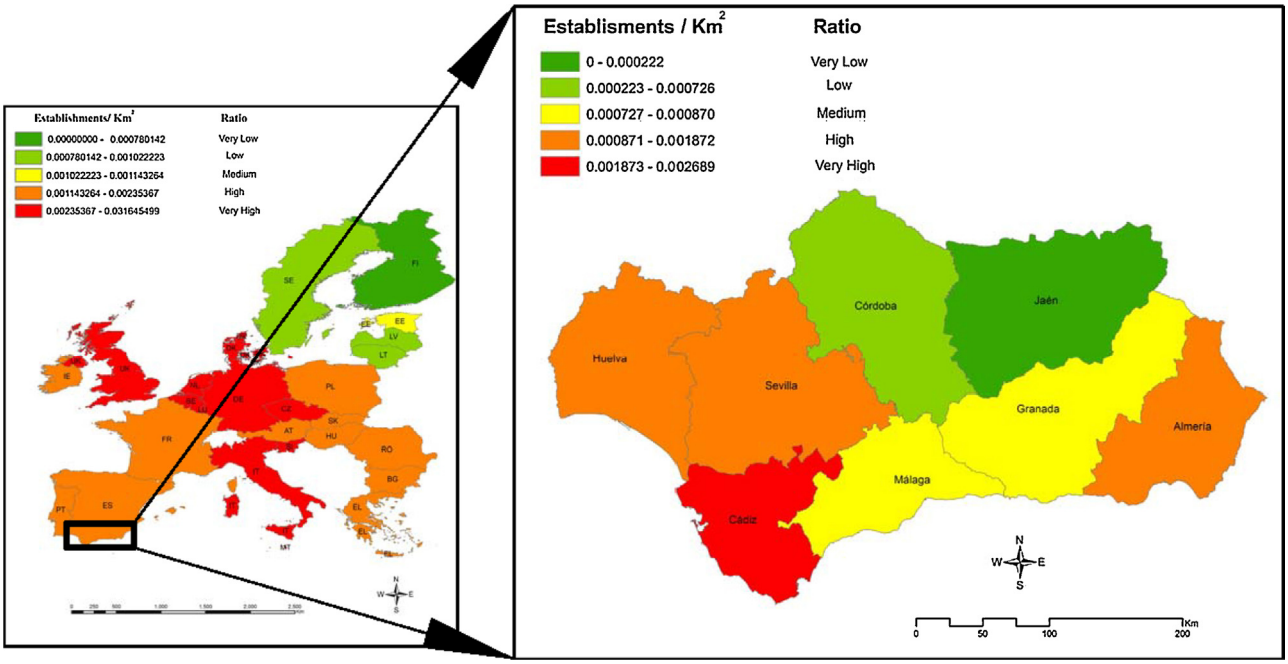

Fig. 1 – Territories classification in the European Union, based on the ratio number of industrial establishments per km^2 (left) and in the particular case of Andalusia (right) (Suffo et al., 2015).

establishments affected by dangerous substances in km^2, which is applied in EU territories. Similarly, and from a comparative perspective, Suffo et al. (2015), presented a ratio of industrial establishments affected by Seveso per unit area (km^2), which was applied in the region of Andalusia (Southern Spain) at the level of provinces and municipalities. Fig. 1 shows the map resulting from the comparison exercise performed by these authors.

This study reinforces the importance of including the value of proximity, besides others already known and used, such as dangerousness, vulnerability and probability/frequency, in the evaluation of the chemical and environmental risk or simply in the evaluation of territorial compatibility. Goerlandt and Montewka (2015) reviewed the previous classification of different definitions of risk proposed by Aven (2012) and concluded that most of these definitions were influenced by the probability or frequency of the occurrence of a certain event. Khakzad et al. (2012) carried out a dynamic risk analysis based on the calculation of probabilities. Moreover, Menoni (2005) and Kontić and Kontić (2009) proposed definitions of the chemical and environmental risk from the perspective of territorial compatibility, taking into account several factors, such as the dangerousness of the substance and the vulnerability of the surroundings. Similarly, Basta (2009), Lewis et al. (2011) and Suffo and Nebot (2015), divided this latter factor into two: the intrinsic vulnerability that is defined as the sensitivity of a certain resource against damage and the extrinsic vulnerability, which is not inherent to the nature of the damaged good but it only considers the effect of the distance from the emitting source of danger (e.g. the industrial establishment), the so-called proximity (Walker et al., 2000). Marzo et al. (2015) suggested a new procedure to assess territorial vulnerability as a consequence of the natural–technological risk (NATECH). The resulting value of the simplified risk assessment or the defined territorial compatibility, must be directly proportional to the first two factors and inversely proportional to the third one:

$$\text{Risk} = K * (\text{dangerousness, Intrinsic vulnerability}) \text{ adopted by the European Environment Agency Glossary (European Environment Agency, 2014)}$$

and,

$$\text{Risk} = K : (\text{Proximity})$$

In particular, in a previous work Suffo and Nebot (2015), applied the above definition of risk to the region of Andalusia (Spain, Europe) and classified territorial areas according to their urban compatibility (Demichela et al., 2014), which is characterized through the quantitative and/or qualitative value of the aforementioned risk. Compatibility or incompatibility of land uses is one of the most basic and most complex components in urban planning. This concept is derived from the term "neighborhood" and it is used to determine the most appropriate form for a city.

No previous works have used the value of proximity as a risk binding factor when, indeed for a correct modeling of the current situation, the accurate knowledge of this value would be essential to establish external emergency plans, land use policies or public information plans (Bier, 2001). All of these measures represent tools to prevent the risk of accidents included in the Seveso Directive. In addition, there are no valid studies able to assist on the use of proximity layers to achieve a reliable risk scale based on the calculation of the average CVR affected.

Argyropoulos et al. (2010), Török et al. (2011) and Christou et al. (2011) compared models for the calculation of the territorial risk using different methods and in none of them a ratio of 1500 m as the maximum range of a BLEVE with irreversible effects for VR was exceeded. Furthermore, TNO Yellow Book (1989) and TNO_Green_Book (1989) suggested dangerous scenarios up to 10 km, although negative effects beyond 3 km were not considered as in Kefalas et al. (2006) and Jo and Ahn (2002). Similarly, risk assessments at distances higher than 3 km are not recommended according to El-Reedy (2012), API-RP580 (2002), and API-581 (2000). Finally, Pape (1989) and Alonso et al. (2008) do not provide calculation models that take into account other larger limits.

2. Material and methods of information gathering

In order to achieve the risk value, we have now selected 40 hazardous substances that have been combined with 101 industrial establishments affected by Seveso, and a list of 16 types of VR have been also chosen, which were distributed among three classes depending on their nature: human, infrastructure and environmental with the aim of analyzing their affectation (Kadri et al., 2013). The analysis performed is shown in Fig. 2. By using the adequate spatial processes in the ArcGIS environment, a total of 25.026 territorial units that can be affected have been identified. These VR are those resources