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Safety Integrated Area Analysis: a Recent Case Study

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The work is mainly concentrated in the theme of relevant accident risk and industrial risk management. The work affords a critical analysis about an integrated safety study area. This study has been conducted recently in a very complex industrial area sited in the oriental part of Sicily, extended along about 21 Km, starting from Augusta city to Syracuse city. This zone has been defined as "great industrial risk area" because of the area is characterized by the presence of very big chemical, petrochemical and energetic industrial plants. The impact of these industrial activity is very important in terms of pollution, territorial degradation and industrial risk.
In the safety integrated area study, industrial installation risks has been associated to the transport of dangerous substances risks. In the paper have been reported the techniques adopted for the identification of potential hazards, estimated their possible consequences and to predispose a risk management planning for the industrial area.

1. Introduction

During the last years, quantified risk assessment (QRA) techniques (CCPS, 2000) have been increasingly used in many risk management decisions. This has been particularly so in Europe, where high population densities, together with a high degree of industrialisation, has forced decision-makers, earlier than elsewhere in the world, to develop methods for evaluating risks.
In Italy, ART. 12 & 13 of the DLGS 334/99 (1999), implementation of European Directive 96/82/CE (Seveso II), introduce the concept of "elevated concentration of industrial plants area" in order to study and mitigate the consequences of potential accidents in a complex industrial area and to determine adequate criteria for the implementation of both prevention and emergency actions.
The main objectives of the ARIPAR project (D.Egidi, et al., 1995) (Analisi e controllo dei Rischi Industriali e Portuali dell'Area di Ravenna - Analysis and control of the Industrial and Harbour Risk in the Ravenna Area), carried out in the period 1988-1992, were:

- the gathering of analytical knowledge of the existing situation in the Ravenna area with respect to risk sources, vulnerability resorts and emergency control centres;
- the development of an "area risk reassembling module" to quantify the risk connected with storage, process and transportation of dangerous substances in the Ravenna area;
- the suggestion of priority interventions to mitigate the consequences of potential accidents.

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The outcomes of the project are undoubtedly very valuable: besides quantitative results, an enormous amount of information concerning the activities involving dangerous substances in the Ravenna area are now available to the central and local authorities.
The ARIPAR project has been developed by the Company Consortium that was charged of the technical development of the project, Snamprogetti, NIER Ingegneria, and DAM, and subsequently optimised by the Chemical, Minerary and Environmental Technologies Engineering Department (DICMA) of the University of Bologna.
In 1995-96 the Institute for Systems, Informatic and Safety (ISIS) of the Joint Research Centre, Ispra, in the framework of the POP Sicily project, modified the original ARIPAR software, running under DOS, to run under Windows platforms. Subsequently, the GIS interface has been added to simplify the use of spatial data and to better represent results on maps.
The Regional Agency for Environmental Protection of Tuscany applied ARIPAR software in two different situations: the integrated area risk study for industrial zone of Piombino and Livorno (ARPAT, 2000).
In both of case the studies quantify the risk connected with the industrial installation present in the area, and suggest some interventions in order to mitigate the risk.
Recently the Regional Agency for Environmental Protection of Veneto (ARPAV, 2006) conducted an integrated area risk study for industrial zone of Porto Marghera (VE), using VARIAR (ANPA, 1997) support system implemented by the National Agency for environmental protection (APAT). Some aspects of the computational modules and related databases have been improved by ARPAV during the study in terms of domino valuation.
The starting point of the presented work is the development of software A.R.I.P.A.R for G.I.S. application in Augusta - Priolo industrial area. The information about the hazards, together with the environmental and demographic information inserted in the data base, have been extracted from the official safety reports. Also the determination of the accidents transports frequency, the meteorology management and the territory discretization have been selected from official safety reports.

2. Something of ARIPAR methodology

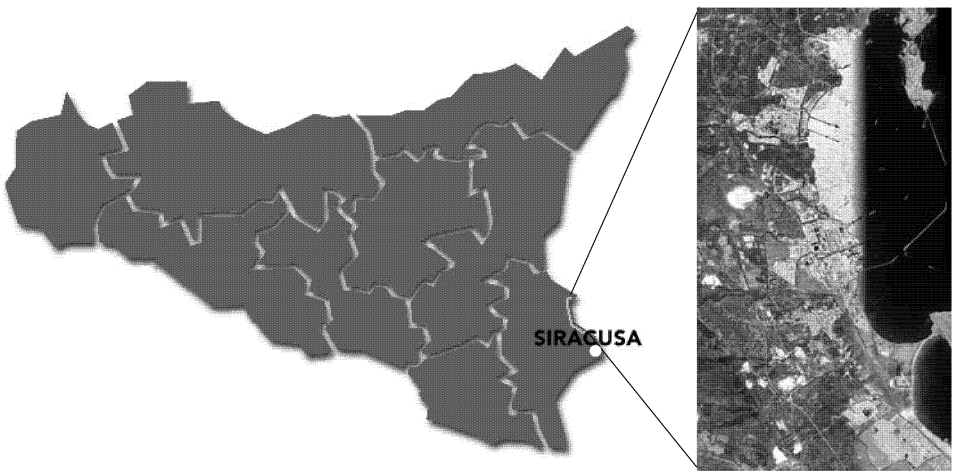
The ARIPAR methodology is based on a set of procedures aimed at the assessment, in quantitative terms, of the risks connected with processing, storage and transportation of dangerous substances in industrial areas.
The risk quantification procedure develops through the evaluation, for all risk sources, of the accidents occurrence frequency and of the consequent event magnitude. Magnitude and likelihood can be combined to produce risk measures:
Local risk: the expected frequency of the reference damage (death of people) occurring as a consequence of any accident, to a person who is permanently occupying (24 hours a day for one year) a certain point of the area, with no possibility of being sheltered or evacuated. It is a figure useful for characterising the risk in a given location. In ARIPAR the local risk has two types of representation, as risk contours, on the overall geographic area, and as a histogram showing, for a given location x, y, the risk value and the contribution of the different risk sources.

Individual risk: the definition is the same of previous one, except that in the evaluation of the reference damage probability some other variables are considered, i.e. the average exposure time, location, and possible protections like staying indoors. It is useful in characterising the risk of a site in relation to its use. The common forms of presentation of the individual risk is the risk contour plot. Places of particular vulnerability (e.g., schools, hospitals, and supermarkets), where there is a significant concentration of people are also considered in the individual risk calculation.
Societal Risk addresses the number of people who might be affected by hazardous incidents. An F-N curve is a plot of the inverse cumulative frequency (F) of accidents from all the different sources capable of provoking the reference damage to a number of people not less than N. The F-N curve is a figure useful for characterising the societal consequences of possible accidents. The frequency F naturally decreases as the number of fatality increases. The limits of risk acceptability are shown as two parallel straight lines on the same diagram, with an area between them in which reduction is desirable. Another useful representation of the societal risk is by means of the I-N histogram, showing the number N of people exposed to an individual risk within the range I, (for example the range 10-6 - 10-5 lethal events/yr.). It is useful in characterising the societal exposure to the risk.

3. "Augusta-Melilli-Priolo" industrial area

The industrial area considered for this study is extended approximately 20 KM near the Augusta coast, Fig.1, limited to North from the city center of Augusta and to South from the Magnisi peninsula, and included part of Melilli, Priolo, Siracusa territory.
This area has been defined in Italy as "great industrial risk area" because of the presence of very big chemical, petrochemical and energetic industrial plants. The impact of these industrial activity is very important in terms of pollution, territorial degradation and industrial risk, and preponderant respect to other anthropic interference with the environmental in the area. Fig. 1

Fig. 1 - "Augusta-Melilli-Priolo" industrial area



From North to South, the industrial installations present in the industrial area: SASOL petrochemical industry, ESSO Italy refinery, UNICEM cement production, ERG MED-N petrochemical industry, POLIMERI EUROPA petrochemical industry, AIR Liquide chemical industry, SYNDIAL petrochemical industry, ISAB Energy petrochemical industry, ERG MED-S petrochemical industry, ISPE chemical industry. Two electric power station are also present in the same area.

4. Safety Integrated Area Study

The mentioned "impact area" could be defined as the area within which the consequences of potential accidents are to be studied.
In 2003 a safety study area has been elaborated, by the industrial installation managers, considering the risk connected to industrial installation and the dangerous substances transport.
A public commission, coordinated by Italian Environmental Protection Ministry, evaluated this study and predisposed a project plan in order to manage the risk, to evaluate domino effects, and to coordinate the information exchange.
In order to have a multidisciplinary approach, several public Agency competent in industrial risk, participated at this commission: National Corps of Fire Brigades, National and Regional Agency for Environmental Protection, Harbor Master's Office of Syracuse, Department of Health, Syracuse Prefecture, etc.
All the Risk Area Commission actions have been coordinated with the Regional Technical Committee activity, that is the public part in Italy delegated to authorize and to control the hazardous industrial installations.
The commission provided some general tasks:

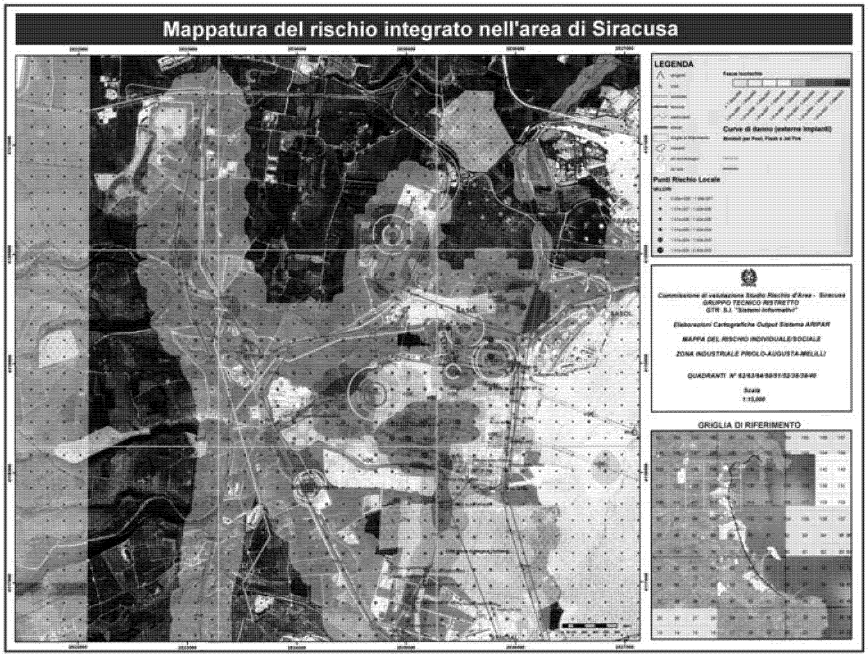
- supplying adequate support system to monitor the industrial activity in the area, and to manage the data useful to risk reassembling;
- homogenization and verification activity of different safety report documents, reported into the paper " Criteria and Assumptions for the Area risk analysis".
- characterize specific project plans to manage the risk area, considering territorial vulnerable elements and also considering pre-existing external emergency plans.

In the framework of the procedure application for area risk analysis developed through the following main steps, schematically represented as:

1. *Description of the geographical interest area:* The first step of the methodology is the definition of the source area, where the risk sources are located, and of the impact area, where the risk has to be determined.
2. *The identification and inventory of accident risk sources:* Storage, process plants and transport of dangerous substances define the risk sources, which exist on a territory where residents, workers and tourist live and could be subject to the consequences of accidents.
3. *The off-line analysis of accident interest scenarios:* This includes identification and evaluation of likely accident scenarios (gas dispersion, fire and explosion events, their probabilities and consequences) for each fixed installation and each type of transport.

4. <u>*The area risk assessment:*</u> The above mentioned measures of local, individual and societal risk are used as indicators of the area risk resulting from the merging of point risk sources (plants) and linear risk sources (different ways of transport). Fig.2.

Fig. 2 - Typical output of Augusta-Melilli- Priolo local area risk reassembling



The ARIPAR methodology uses a numerical procedure able to overcome computational difficulties arising from:

- the non symmetric distribution of local and individual risk around sources, when scenarios depending on wind rose must be simulated;
- the need to manage a large number of accident scenarios;
- the presence of linear risk sources, caused by accidents travelling with vehicles (trucks, trains, ships) or with mass flows (in pipelines), which must be represented by many point sources (segments of fixed lengths).

Values of local and individual risk are calculated for the centres of the cells of a non regular grid superimposed to the impact area. At the same points the distributed population is clustered for societal risk evaluation purposes, so that an accurate choice of cells dimension must be done to assure a good compromise between accuracy of results and acceptable computation time.

Time saving is also the aim of interpolation functions through which accident conesquences are modelled. The results of each single accidental scenario, available from numerical codes for discrete points only, are substituted by continuous functions representing the time and/or spatial distribution of concentrations, over pressures and thermal radiation.

With the aim to eliminate, or at least to mitigate or to contain the critical aspects emerged from the area risk study, different activities have been proposed:

- activities useful to eliminate critical managerial or technical aspect;
- activities useful to reduce the consequences of potentially accidents;
- to estimate the global effect that proposal projects induce on the integrated area risk and to evaluate these effects in specific zone;
- to program common co-ordinate actions between private and public parts in order to monitor the area.

5. Conclusions

It is fundamental to emphasize that the private and public Commission activities would not have to be exausted in realization of this integrated area risk, and in the proposal of possible safety measures within of industrial installation plants and territorial infrastructures, but comprise a global territorial appraisal, proposing a detailed realization program and implementing a performance and effectiveness monitoring modality relative to the proposed safety projects.
Economic and technical necessary resources would have supply to Public institutions in order to permit sensibility system analyses, to identify more effective safety actions, to evaluate alternatives actions and relative financial and/or social benefits. All that represents the unavoidable base for the decisional processes, for the information of the population and for the future monitoring actions.
It is evidenced moreover as the relative local risk mapping information and the risk critical factors location are very important to complete the decisional processes relative to territory and urban planning.
Considering the particular features of vulnerability of the sicilian territory, the information obtained allow the mapping of global risk giving a fundamental contribution for activities of territorial planning and for the emergencies management.

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